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On the Construction of the Screw Propeller of Uniformly Expanding Pitch. By D. M. GREENE, U. S. Naval Engineers.

In projecting the working plans of the screw propeller of uniformly expanding pitch, the practice of draftsmen is not only variable, but signally defective in system, and in many cases totally wanting in accuracy. In many instances, screws constructed from drawings intended to represent screws with uniformly expanding pitches, are neither what they were designed to be, true screws, or, indeed, screws of any description whatever. They may with propriety be called *propellers*, but never screws.

The best method now practiced in "laying down" the screw, is, in our opinion, that which regards the subject as simply a problem in descriptive geometry; and determines all the elements, except those expressing the conditions of the question, by a system of projections. This method, however, is tedious; and the results, notwithstanding the greatest care may be observed in the construction, are vitiated by errors which unavoidably creep in and accumulate as the work progresses. Nor is this all; the sections of the screw blade determined by this method, are not real sections, but are merely projections of the curves of the blade upon planes, with the actual thicknesses of the blade laid off upon these projections; thus making sections which are neither the actual sections of the blade or projections of them.

How, then, can the pattern-maker and moulder be expected to furnish us with perfect screws?

We are of those who believe that, if there is any merit in the screw of uniformly expanding pitch, advantage can be taken of it only by making it so. With this view, we have constructed a formula for calculating the ordinates of the curve of the guide-plate used in sweeping up the mould, and have adopted a new method of constructing the sections of the blades.

To construct the formula, suppose the guide-plate constructed; and let A B C, Fig. 1, (Plate I,) represent its development (exaggerated of course) upon a plane parallel to the axis of the screw. A C will be the portion of the circumference occupied by one blade, and B C will be the length of the screw, or the terminal ordinate of the developed helix A B.

Divide A C into n equal parts; erect ordinates to the curve at each point of division, and conceive tangent lines drawn to the curve at the points where these ordinates meet it. The angles which these tangent lines make with A C, at their respective points of tangency, will be the angles of the screw at those points.

Let θ = angle of the screw at posterior edge A.
θ' = " " " anterior " B.
φ = pitch " " posterior "
φ' = " " " anterior "

x = each of the equal divisions of AC = $\frac{AC}{n}$.

y_1, y_2, y_3, &c. = ordinates to the points a, b, c, &c., of the developed helix.
R = radius of the screw.
c = circumference of the screw.
K = decimal, expressing the part of the circumference occupied by one blade.

Before proceeding further, however, let us examine the nature of the curve A B for a moment. If Δ represent the slight decrease in pitch between A and a, (of course the pitch *decreases* from the after to the forward side,) there will be a like decrease of pitch between a and b, b and c, and so on to B; hence if

φ = pitch at A,
$\varphi - \Delta$ = " " a;
$\varphi - 2\Delta$ = " " b;
. . . . . .
and $\varphi - n\Delta = \varphi'$ = " " B.

Now it will be remembered by those familiar with the screw, that the tangent of the angle of a screw is equal to the pitch divided by the circumference. We shall, therefore, have for the tangents of the angles of the screw at the successive points of the developed helix—representing these angles by $\theta, \theta_1, \theta_2, \ldots \theta_n = \theta'$—

$$\tan \theta = \frac{\varphi}{2\pi R} = \frac{\varphi}{c}.$$

$$\tan \theta_1 = \frac{\varphi - \Delta}{c}.$$

$$\tan \theta_2 = \frac{\varphi - 2\Delta}{c}.$$

$$\tan \theta_3 = \frac{\varphi - 3\Delta}{c}.$$

. . . . . .

$$\tan \theta_n = \tan \theta' = \frac{\varphi - n\Delta}{c} = \frac{\varphi'}{c}.$$

Subtracting,

$$\tan \theta - \tan \theta_1 = \frac{\varphi}{c} - \frac{\varphi - \Delta}{c} = \frac{\Delta}{c}.$$

$$\tan \theta_1 - \tan \theta_2 = \frac{\varphi - \Delta}{c} - \frac{\varphi - 2\Delta}{c} = \frac{\Delta}{c}.$$

$$\tan \theta_2 - \tan \theta_3 = \frac{\varphi - 2\Delta}{c} - \frac{\varphi - 3\Delta}{c} = \frac{\Delta}{c},$$

&c.; hence, we see that the tangents of the angles of the screw diminish by a constant difference; *i.e.*, uniformly from the after to the forward edge of the blade; or *increase* by a constant difference from the forward to the after part.

Having established this point, we are prepared to proceed with the construction of the formula. Putting the constant difference found above, $\frac{\Delta}{c} = \delta$. We have also,

$$\delta = \frac{\tan \theta - \tan \theta'}{n}$$

$$= \frac{\frac{\varphi}{c} - \frac{\varphi'}{c}}{n}$$

$$= \frac{\varphi - \varphi'}{cn}, \quad . \quad . \quad . \quad (1.)$$

Now, $y_1 = x \tan \alpha_1$.

But, $\alpha_1 = \theta - f \text{A} a$,

and since $f \text{A} a$ is the angle included between the tangent to the curve at A and the chord A a, the difference—in this particular case—between the tangent of θ and the tangent of α_1, due to $f \text{A} a$, will be equal to *half* the common difference of the tangents of the angles which the consecutive chords make with A C; and, consequently, equal to half the common difference of the tangents of the angles which the consecutive *tangent lines* make with the A C. This common difference being δ, we shall evidently have $\tan \alpha_1 = \tan \theta - \frac{\delta}{2}$,

$$\therefore y_1 = x\left(\tan \theta - \frac{\delta}{2}\right). \quad . \quad . \quad . \quad (2.)$$

But, $$x = \frac{\text{A C}}{n} = \frac{\text{K } c}{n},$$

which, being substituted in (2), together with the values of θ and δ already found, gives

$$y_1 = \frac{\text{K } c}{n}\left(\frac{\varphi}{c} - \frac{\frac{1}{2}\varphi - \frac{1}{2}\varphi'}{c\,n}\right)$$
$$= \frac{\text{K } c}{n}\left(\frac{\varphi n - \frac{1}{2}\varphi + \frac{1}{2}\varphi'}{c\,n}\right)$$
$$= \frac{\text{K}}{n^2}\left[\varphi(n - \tfrac{1}{2}) + \tfrac{1}{2}\varphi'\right]. \quad . \quad . \quad . \quad (3.)$$

Again, $$y_2 = y_1 + x \tan \alpha_2.$$

But, $$\alpha_2 = \alpha_1 - d\,a\,b,$$

and $d\,a\,b$, being the angle between the two consecutive chords A a and $a\,b$, and equal to the angle between two consecutive tangents, the difference between the tangents of α_1 and α_2 will evidently be δ. So, also, will the differences between tan α_2 and tan α_3, tan α_3 and tan α_4, &c., each be equal to δ; hence, the preceding value of y_2 becomes

$$y_2 = y_1 + x(\tan \alpha_1 - \delta)$$
$$= y_1 + x(\tan \theta - \tfrac{3}{2}\delta).$$

Substituting, as before, the values of x, tan θ, and δ, and also placing for y_1 its value from (3), we have

$$y_2 = \frac{\text{K}}{n^2}\left[\varphi(n - \tfrac{1}{2}) + \tfrac{1}{2}\varphi'\right] + \frac{\text{K } c}{n}\left(\frac{\varphi}{c} - \frac{\frac{3}{2}\varphi - \frac{3}{2}\varphi'}{n\,c}\right)$$
$$= \frac{\text{K}}{n^2}\left[\varphi(n - \tfrac{1}{2}) + \tfrac{1}{2}\varphi'\right] + \frac{\text{K}}{n^2}\left[\varphi(n - \tfrac{3}{2}) + \tfrac{3}{2}\varphi'\right]$$
$$= \frac{\text{K}}{n^2}\left[\varphi(2n - \tfrac{4}{2}) + \tfrac{4}{2}\varphi'\right], \quad . \quad . \quad . \quad (4.)$$

In an entirely similar manner, and for the same reasons, we obtain

$$y_3 = y_2 + x(\tan \theta - \tfrac{5}{2})\delta.$$

Substituting values, this becomes

$$y_3 = \frac{\text{K}}{n^2}\left[\varphi(2n - \tfrac{4}{2}) + \tfrac{4}{2}\varphi')\right] + \frac{\text{K } c}{n}\left(\frac{\varphi}{c} - \frac{\frac{5}{2}\varphi - \frac{5}{2}\varphi'}{c\,n}\right)$$
$$= \frac{\text{K}}{n^2}\left[\varphi(2n - \tfrac{4}{2}) + \tfrac{4}{2}\varphi'\right] + \frac{\text{K}}{n^2}\left[\varphi(n - \tfrac{5}{2}) + \tfrac{5}{2}\varphi'\right]$$
$$= \frac{\text{K}}{n^2}\left[\varphi(3n - \tfrac{9}{2}) + \tfrac{9}{2}\varphi'\right], \quad . \quad . \quad . \quad (5.)$$

Similarly,

$$y_4 = \frac{\text{K}}{n^2}\left[\varphi(4n - \tfrac{16}{2}) + \tfrac{16}{2}\varphi'\right], \quad . \quad . \quad . \quad (6,)$$

$$y_5 = \frac{\text{K}}{n^2}\left[\varphi(5n - \tfrac{25}{2}) + \tfrac{25}{2}\varphi'\right], \quad . \quad . \quad . \quad (7,)$$

&c. Examining, now, the values of y_1, y_2, y_3, &c., we observe that

the co-efficient of n, in the parenthesis, is in each case equal to the number of the ordinate from the beginning of the curve; also, that the numerators of the factions are equal to each other, and equal to the *square* of the number of the ordinate. We are, therefore, enabled to write, at once, the general formula for the value of the mth ordinate, thus;

$$y_m = \frac{\kappa}{n^2}\left[\varphi\left(mn - \frac{m^2}{2}\right) + \frac{m^2\,\varphi'}{2}\right], \quad . \quad . \quad (8.)$$

If, now, we make $m = n$, (8) becomes

$$y_n = \frac{\kappa}{n^2}\left[\varphi\left(n^2 - \frac{n^2}{2}\right) + \frac{n^2\,\varphi'}{2}\right]$$

$$= \frac{\kappa\, n^2}{n^2}\left(\frac{\varphi + \varphi'}{2}\right)$$

$$= \kappa\left(\frac{\varphi + \varphi'}{2}\right) = l, \quad . \quad . \quad . \quad . \quad (9.)$$

If, again, we make $\kappa = 1$, or, if we extend the blade entirely round the axis, (9) becomes

$$y_n = \left(\frac{\varphi + \varphi'}{2}\right) = \text{mean pitch},$$

which proves the correctness of our formulæ.

It will be observed that the ordinates computed by the aid of the general formula (8) are each entirely independent of all the others, and, consequently, not affected by accumulative numerical errors, or by errors of construction. Each ordinate thus computed, can be laid down as accurately as it is possible to lay down any computed distance.

In the case of a screw having a uniformly varying pitch from hub to periphery—if such a screw, or *propeller*, were desirable—our formula is equally applicable, it being only necessary to construct guide curves at equal intervals from hub to periphery, or simply *two* curves, one at the hub and the other at the periphery. We should have remarked before, that the ordinates calculated for the periphery of a screw of uniformly varying pitch, "fore and aft," answer equally as well for all the sections between the periphery and hub, as for the curve the curve of the guide-plate.

EXAMPLE.—Let $\varphi = 24$ feet, $\varphi' = 20$ feet, $\kappa = \cdot 16$, and $n = 10$. Then will

		1*st dif.*	2*d dif.*
$y_1 = \frac{\cdot 16}{100}\left[24\left(10 - \frac{1}{2}\right) + \frac{20}{2}\right]$	$= \cdot 3808$	$\cdot 3808$	
$y_2 = \frac{\cdot 16}{100}\left[24\left(2\times 10 - \frac{4}{2}\right) + \frac{4}{2}\times 20\right]$	$= \cdot 7552$	$\cdot 3744$	$\cdot 0064$
$y_3 = \frac{\cdot 16}{100}\left[24\left(3\times 10 - \frac{9}{2}\right) + \frac{9}{2}\times 20\right]$	$= 1\cdot 1232$	$\cdot 3680$	$\cdot 0064$
$y_4 = \frac{\cdot 16}{100}\left[24\left(4\times 10 - \frac{16}{2}\right) + \frac{16}{2}\times 20\right]$	$= 1\cdot 4848$	$\cdot 4616$	$\cdot 0064$

$$y_5 = \frac{\cdot 16}{100}\left[24\left(5\times 10-\frac{25}{2}\right)+\frac{25}{2}\times 20\right] = 1{\cdot}8400 \quad \cdot 3552 \quad \cdot 0064$$

$$y_6 = \frac{\cdot 16}{100}\left[24\left(6\times 10-\frac{36}{2}\right)+\frac{36}{2}\times 20\right] = 2{\cdot}1888 \quad \cdot 3468 \quad \cdot 0064$$

$$y_7 = \frac{\cdot 16}{100}\left[24\left(7\times 10-\frac{49}{2}\right)+\frac{49}{2}\times 20\right] = 2{\cdot}5312 \quad \cdot 3424 \quad \cdot 0064$$

$$y_8 = \frac{\cdot 16}{100}\left[24\left(8\times 10-\frac{64}{2}\right)+\frac{64}{2}\times 20\right] = 2{\cdot}8672 \quad \cdot 3360 \quad \cdot 0064$$

$$y_9 = \frac{\cdot 16}{100}\left[24\left(9\times 10-\frac{81}{2}\right)+\frac{81}{2}\times 20\right] = 3{\cdot}1968 \quad \cdot 3296 \quad \cdot 0064$$

$$y_{10} = \frac{\cdot 16}{100}\left[24\left(10\times 10-\frac{100}{2}\right)+\frac{100}{2}\times 20\right] = 3{\cdot}5200 \quad \cdot 3232 \quad \cdot 0064$$

In the value of y_{10}, if we put unity for ·16, the value of y_{10} becomes 22 feet $= \frac{24+20}{2}$ = mean pitch. It will be observed, also, that the second differences are constant, both of which facts prove the accuracy of our results.

We now proceed to illustrate our method of constructing the working drawing of the screw given in the preceding example, so far as it is essentially different from the methods we have seen employed.

Let R = 8 feet; Draw K K′, Fig. 3, (Plate I,) as the centre line of the blade and its sections; take any point E as a centre, and with a radius equal to the radius of the screw, describe an indefinite arc. Calculate ·16 of 360° = 57° 48′, and lay off half of this angle on each side of K K′; the sector E F H thus determined, will represent the projection of one blade on a plane perpendicular to the axis. Next, divide the radius into any number of equal parts, say four, and through the points of division draw the arcs *a b*, *c d*, and *e f*, concentric with F H; also, draw an arc, A C, 6 inches outside the periphery to represent the position of the *guide-plate*.

Now, divide the arc A C into any convenient number of equal parts, generally ten; but in this case we only use five. Through the points of division draw radii dividing the projection of the blade into five equal sectors. Next calculate the circumference for the radius A E = 8′ 6″, and find ·16 of that circumference, which will be 8′·5452. Draw A′ C′ tangent to A C at its middle point; make it equal to 8·5452 feet; divide it into five equal parts, and draw lines from A′C′ and the points of division, to the centre E; also, draw tangents to the middle points of each of the arcs F H, *a b*, *c d*, and *e f*.

Then will A′ C′, F′ H′, *a′ b′*, *c′ d′*, *e′ f′* be the developments of the corresponding arcs, upon the tangents drawn to their middle points, and, consequently, perpendicular to K K′. The intersections of these tangents by the lines drawn from A′ C′ to the centre, will evidently be equidistant, and represent the positions of the points of division of the arcs, in their respective developments.

Next, upon the opposite side of E, at equal intervals, each slightly greater than the length of the screw, (or the greatest computed ordi-

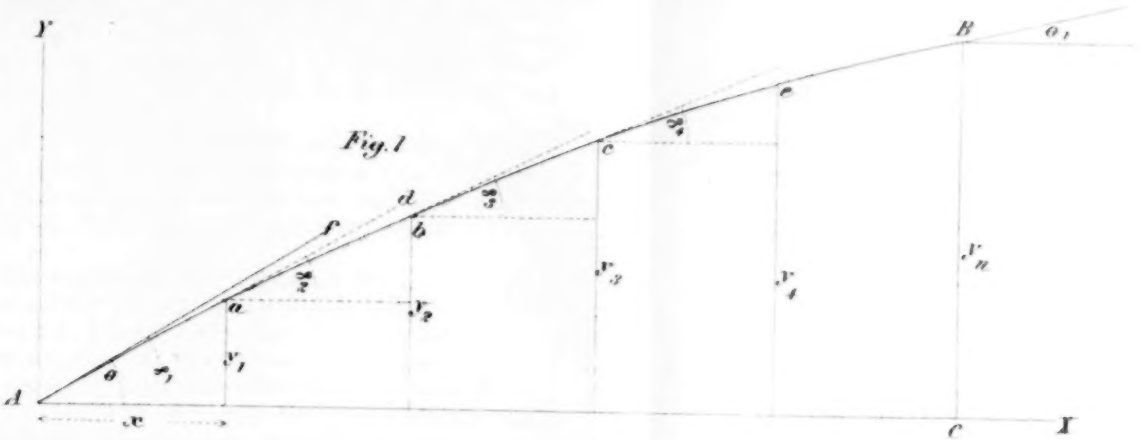


Fig. 1

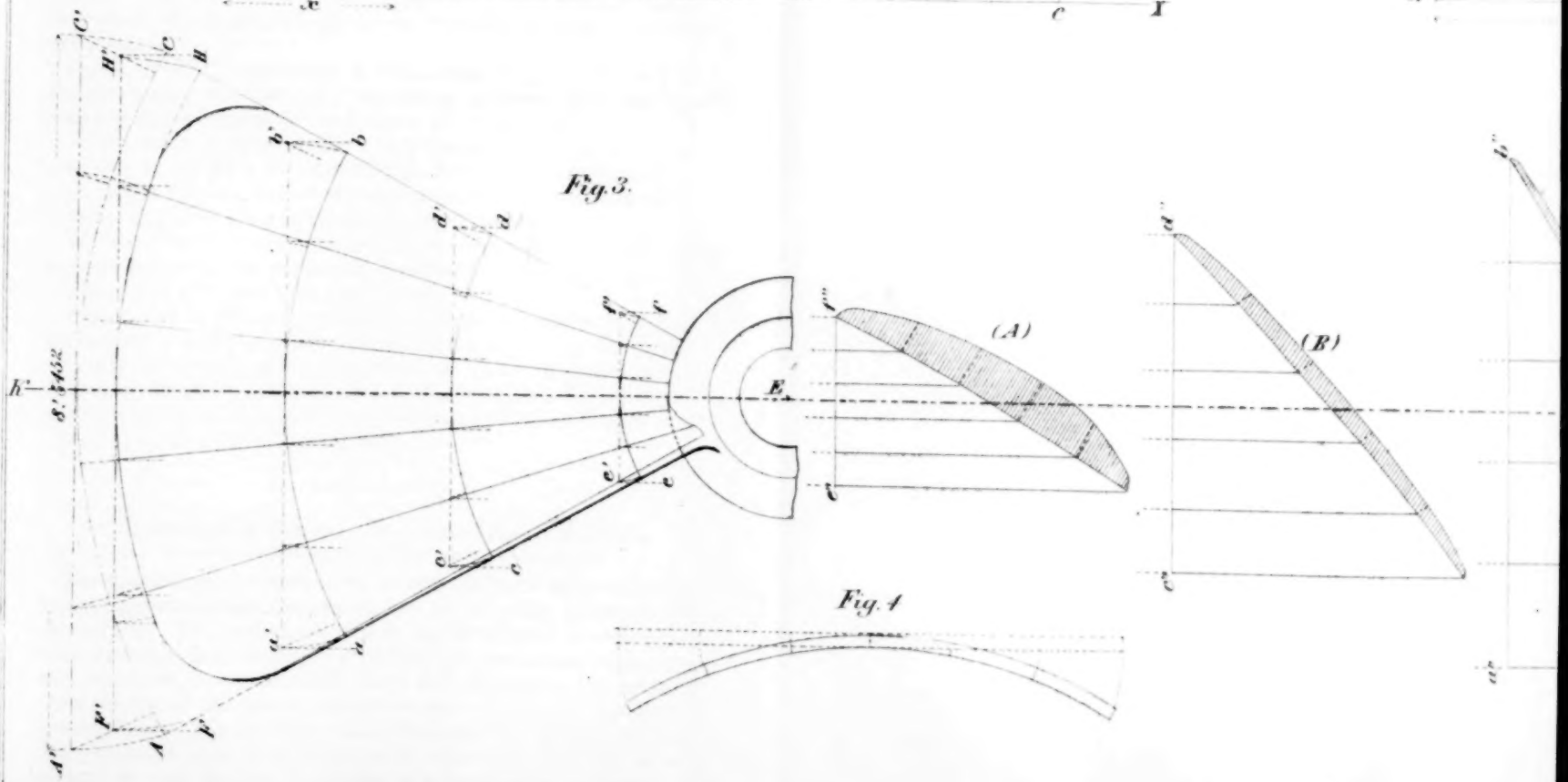
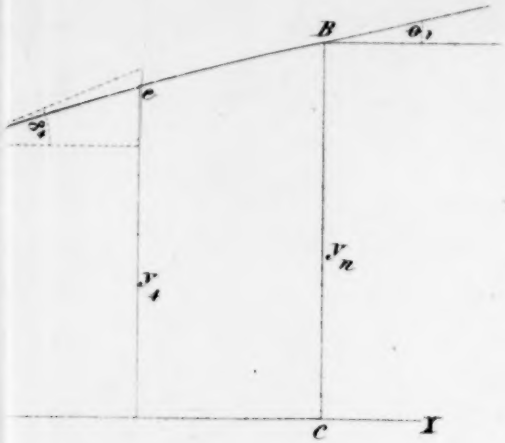
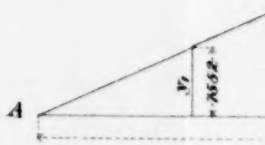


Fig. 3.

Fig. 4





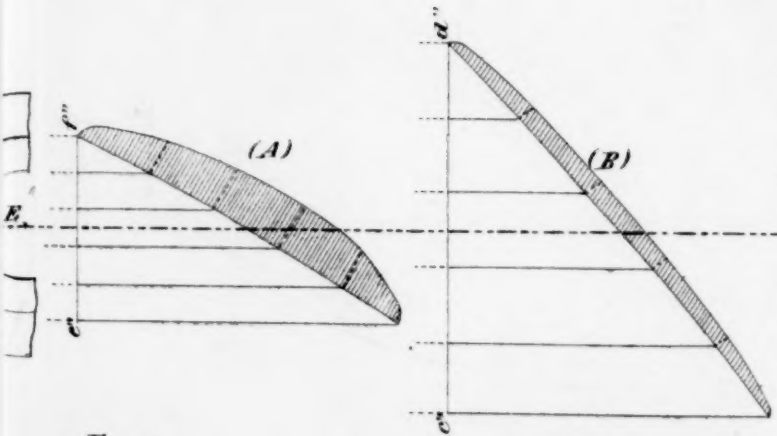
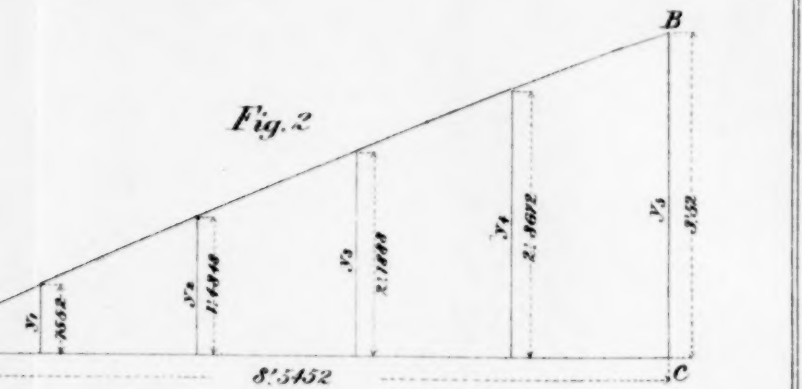
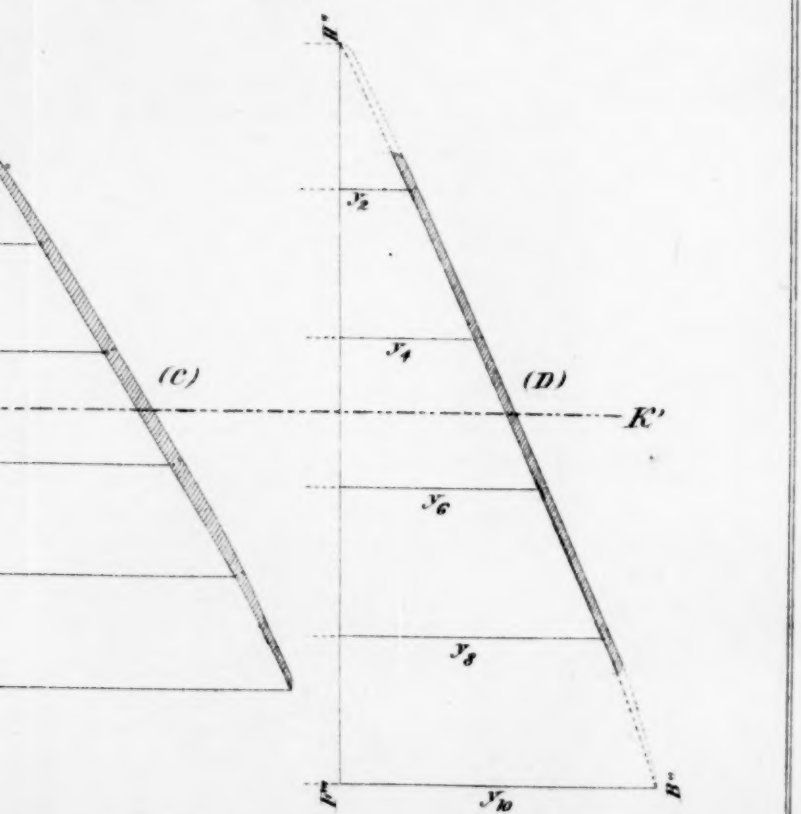


Fig. 4


B
Fig. 2
y1
.852
y2
1.6440
y3
2.1888
y4
2.8672
y5
3.132
8.5452
C


B'
y2
y4
(C)
(D)
K'
y6
y8
B''
y10

nate,) draw as many perpendiculars to K K′, as there are arcs upon the blades. Then project the extremities and points of division of F′ H′, in lines parallel to K K′, upon the most remote of the perpendiculars last drawn; and in like manner project $a'\,b'$, $c'\,d'$, and $e'\,f'$ upon corresponding perpendiculars; F′ H′ will then be found in F″ H″, $a'\,b'$ in $a''\,b''$, $c'\,d'$ in $c''\,d''$, and $e'\,f'$ in $e''\,f''$.

Finally, lay off at the points of division of F″ H″ the ordinates y_2, y_4, y_6, y_8, y_{10}, already computed, and draw a curve through their extremities; in like manner lay off these same ordinates at the points of division of $a''\,b''$, $c''\,d''$, and $e''\,f''$, and draw curves through their extremities.

The curves thus constructed will represent the exact lengths (not projections as is usually the case) of the parallel helices of the blade, of which the arcs F H, $a\,b$, $c\,d$, and $e\,f$ are the projections. Laying off upon these curves the proper thicknesses of the blade, and drawing another set of curves through their extremities, we have the sections (A), (B), (C), and (D) of the blade represented in their actual dimensions; from which the measurements for the "thickness strips" can be directly taken.

Fig. 4, (Plate I,) represents a "thickness strip," made in a single straight piece; then cut away, by sawing, at small intervals, so that it may be easily bent to fit the circular arc of the blade.

To construct the drawing for the guide-plate, Fig. 2, (Plate I,) we have only to lay off A C = 8·5452 feet, divide it into five equal parts, erect perpendiculars, lay off the computed ordinates at the points of division, and draw a curve through their extremities.

We have, in this example, used only *five* ordinates, that number being sufficient for our purpose of illustration. In a working drawing, however, it is of course better to use ten.

Figs. 2 and 3, (Plate I,) comprise all that is necessary in a working drawing of a screw propeller of uniformly expanding pitch; excepting, only, the length of the hub, which we have not represented, and the *sweep*, which, in the case of a blade curving backward, would require a representation either of the sweep or of its curvature.

Washington, D. C., November 15, 1865.

Ventilation of Sewers. By James Lemon, A.I.C.E.

From the Civil Engineer and Architect's Journal, November, 1865.

The ventilation of sewers is one of those subjects upon which a great many suggestions have been made, but still very few of them have been carried out. The system adopted in the Metropolis (excepting in the main drainage) is exceedingly primitive: it consists, as many persons well know, of a vertical shaft about 3 ft. square in the clear, built upon the top of the sewer, and covered at the top by means of two gratings about 2 ft. by 6 ins. each, flush with the surface of the road. The results of this arrangement are: the smell from the sewage is allowed to pass up into the streets at a level where it is most objec-

tionable and the foul gases are inhaled by the persons passing; likewise, the gratings become choked with the mud and stones from the roads, or the bottom of the sewer becomes full of deposit washed or swept down the ventilators. In the main drainage system there is a cesspit about 2 ft. 6 ins. square by 6 ft. in depth under the ventilating gratings which receives the detritus from the roads. This cesspit is connected with a vertical shaft adjoining thereto, built over the sewer in the same manner as the ordinary ventilating shafts. In the wall between the cesspit and the shaft there are two openings, one next the bottom fitted with a small iron grating to allow the water to drain off and to prevent the passage of stones, &c., into the sewer; the other for ventilation, which is intended to be fitted with trays containing charcoal, so that the foul gases may be disinfected. In this method, however, the choking of the gratings is not remedied, therefore it cannot be considered one that can be recommended for general adoption.

The sewers of Paris are ventilated by means of iron pipes, which are connected with the branch sewers or house drains, and are carried up either in the thickness of the front walls of the houses, or outside the walls to the top of the roof. This plan, in some instances, has been objected to; but if the joints were screwed and securely fitted, the inlet connected with a charcoal filter in the sewer, and the outlet carried up above the roof of the house or adjoining building, there can be no reason why it should not be the best mode of ventilation that has yet been devised. One of the chief causes of complaint in Paris is the imperfect way in which the gullies or inlets for the street drainage are constructed; they are in some cases trapped, but the trapping is certainly not efficient, as the smell therefrom in some of the best parts of the city is very offensive.

Amongst the many modes of ventilation which have been proposed, there is one which might be easily adopted in the manufacturing districts, and that is to utilize, with consent of the owners, the tall chimneys, by connecting them with the ventilating shafts of the sewers; this would promote a current of air through the sewers, and draw off the noxious gases. Ventilation of sewers might also be effected by carrying up an iron tube in the centre of the lamp standards at the crossings of the main streets, similar to those in Southwark street, London, the inlet being connected with a charcoal filter in the shaft from the sewer. This mode could not, from the isolated position of the outlet, be a nuisance to the occupiers of the houses in the locality, and would be an improvement on the present ventilators in the centre of the streets, flush with the surface of the roadway. Advantage might also be taken of the end walls at the corners of streets for carrying up ventilating tubes to the tops of the houses, as in Paris, so as to remove the objection to ventilation. A very curious mode of ventilation was suggested by Admiral Sir E. Belcher, which may be thus described: the foul air was to be taken from the sewers by means of a pipe connected therewith, and carried up to the top of the lamp-posts, and there discharged. This rather novel way of mast-heading the stink, although it may be very nautical, might be objected to by per-

sons occupying the first floors of houses opposite the outlet; in fact, the gallant admiral himself would find it somewhat unpleasant if he happened to be sitting at an open window to the leeward.

Side Entrances.—The side entrances to sewers should not be made, as a rule, more than 1000 feet apart; they bear a small proportion to the whole cost, and they are exceedingly convenient for repairs, making connexions to house drains, cleansing, &c.; they should in every case be provided with a ventilator and cesspit, so that foul gases may not collect in the entrance shaft. The most convenient place for placing a side entrance is at the corner of a cross street, so that it may be available for access to the junction of the sewers at that point. Side entrances are usually constructed with an entrance shaft from 2 ft. 6 ins. to 3 ft. square in the clear, with a horizontal gallery or chamber to the sewer about 6 ft. 6 ins. in height by the width of the shaft. A very useful size for the entrance shaft is 3 ft. by 2 ft. 6 ins. Iron ladders, for access thereto, are much preferable to foot irons, and are now being adopted in most modern works constructed by well known drainage authorities. The entrance covers should be made as light as possible consistent with strength, and should be provided with wrought iron gratings so constructed that both could be easily opened by one man from the *inside*. The cast iron covers and gratings used under the Metropolitan Commissioners of Sewers are excessively heavy and clumsy, weighing between 4 and 5 cwt., so that if a workman should happen to be in the sewer and the flap become accidently closed, he would be completely trapped, and must wait until he receives assistance from above.

Side entrances might be more extensively used with advantage in pipe drainage, or, as they might be more strictly termed, shafts, for the purpose of inspection, flushing, &c. These shafts could be sunk below the level of the bottom of the pipe sewer, so as to form cesspits; on the lower side of the shafts nearest the outlet penstocks could be fixed, so that a head of water could be raised at each shaft, and the pipe sewer flushed as far as the next shaft, into the cesspit, at which point, when sufficient head was obtained, the penstock could be raised, the next length flushed, and so on to the outlet.

Junctions.—The junction of branch sewers with the main sewer should be made on a regular curved line, with a radius not less than 30 ft. The level of the invert of the branch sewer should be above that of the main sewer, such difference of level should be equal to the difference of height of their respective inverts, or in other words, the arches should spring from the same level. It is recommended by Mr. Rawlinson that the fall of curved junctions should be increased, to compensate for friction; where sufficient fall can be obtained such increased gradient will no doubt be advantageous. Bell-mouthed junctions should be provided with ventilators and cesspits, to allow the foul gases to pass off at the highest point where they mostly accumulate.

House Drains.—House drains should in every case be formed of glazed stoneware pipes; they should be well laid to a regular gradient on a sound foundation of the maiden ground, or of concrete, so

that no settlement might take place, and thereby cause deposit, and ultimately stoppage. Drainage should not be taken through the houses under the floors if it can by any means be avoided. Water closets should be placed next external walls, so that they may be drained as direct as possible. Sinks should be connected with the drain of the water-closets, so as to flush it with the house washings, also the overflow from the waste of the cisterns.

A six-inch glazed drain pipe, with a proper fall, will be sufficient for the entire drainage of an eight-roomed house, and four-inch pipes for the sink and rain-water. Drain pipes should be connected with the sewer on a curved line, and the drain mouths should be provided with galvanized iron shackle-flaps, to prevent smell or flood waters from rising up the house drains. All drains should be trapped by means of a syphon bend, or other suitable arrangement, at a point easy of access in case of stoppage; also, all inlets for surface drainage of yards, areas, &c., should have cesspits, with syphon overflows, as one of the surest means of preventing deposit in drains is to check the admission of sand and other matter at these points.

Resistance of Water to Floating and Immersed Bodies.

From the London Mechanics' Magazine, September, 1865.

Prof. Rankine read an interim report of the Committee appointed for experimenting on the difference between the resistance of water to floating and immersed bodies. The experiments not being complete, the committee deferred a detailed report. The committee had several meetings during last winter and spring, and agreed to a programme of experiments. Two models of ship-shape, four feet long and painted, were made and employed in those experiments. The experiments were made according to the method formerly put in practice by Mr. Scott Russell, in which the uniformity of the propelling force was maintained by means of a regulating weight hanging from a pulley, under which the hauling cord passes, the model being guided in a straight course by means of a stretched wire. The experiments were made with the models both totally immersed and only half immersed. The execution of the experiments was superintended by Mr. Scott Russell, as being the only member of the committee resident in or near London. The actual performance of the experiments was entrusted by Mr. Russell to Mr. J. Quant, who had performed the duty with great skill and assiduity. A lake in Blackheath Park was kindly granted for the experiments by Dr. Joseph Kidd. Twenty-eight experiments had been made on the first model, with the following results: 1. The resistance, when immersed so as to be just covered with water and no more, was more than double its resistance when half immersed, at the same speed. 2. When the after body of the model was turned so as to convert the water-line into buttock-line, its resistance was increased, and that whether the model was half immersed or just covered. The report deferred the detailing the description of the experiments until they should be completed.

For the Journal of the Franklin Institute.

Leveling and Surveying by Means of a Visual Angle and Rod.

By S. W. Robinson, C. E.

In the February number of this *Journal*, for 1865, will be found a paper written upon this subject.

My chief object was there to give a rigorous analysis of the problem of leveling, and of measuring distances by means of a visual angle and rod, and to derive therefrom formulæ, accurate and also approximate, suitable for practical use. I considered the question with reference to holding the rod normal, or perpendicular, to the central visual ray, and to the horizon; and also adapted the analysis to an unequal division of the visual angle, allowing the middle thread of the reticule of the telescope to be that centered upon the target when measuring the vertical angle,—the target being attached to the rod, or painted upon the stadia. I also considered in the analysis the correction due to a change of the focus of the telescope for the stadia at small and greater distances, and gave the maximum amount of error which would follow from neglecting it entirely.

In the January number of the same volume of the *Journal*, there appeared a valuable article upon a similar subject, by Mr. J. R. Mayer, C.E. His formulæ agree exactly with the approximate formulæ which I gave, though neither had any knowledge of the doings of the other in the matter, until the results appeared in the *Journal*. He did not give the amount of, nor even mention the fact that the adjustment of the focus of the telescope for a satisfactory reading of the stadia at small and great distances is a source of error unaccounted for in the formulæ. I found, however, that the maximum error from this cause never exceeds about one and a half times the focal length of the object-glass in the horizontal measure, and the same multiplied by the sine of the vertical angle in vertical measure.

This error, it is plain, arises from a change in the magnitude of the visual angle, on account of adjusting the reticule—which should be constantly in the focus of the eye-glass for the same eye—to a proper distance from the object-glass for viewing the stadia in various positions. And it is also plain that for the stadia at the same distance from the object-glass, the reticule must always be brought to the same distance from it also. This will follow whether the eye of the observer be short or long sighted, because the focal length of the object-glass is entirely independent of it. Thus, if a screen be placed behind a convex lens or an object-glass, and the image of any object brought out distinctly upon it, and, if for the screen a reticule of wires be substituted, then the reticule will be in the focus of the glass. And now if the reticule be viewed by an eye-glass, both the image and reticule will appear together. Now, if the reticule and image be viewed by a different eye of different focus, it is only necessary to extend or retract the *eye-glass** slightly, when they will both appear to the new ob-

* Not the eye-piece, unless regarded as distinct from the slide carrying the reticule. In the inverting telescope where the Ramsden's eye-piece is used, the slide-tube usually carries both the eye-glass, or eye-piece and the reticule, which are kept at the same constant distance from each other, except when adjusting for the focus of the eye.

server as perfectly as they did to the other, without having changed the relative positions of the reticule and object-glass. All this is true of the telescope of the stadia instrument.

From this fact it is plain that *the only necessary change to adapt any stadia instrument to the use of any observer, is simply a proper adjustment of the eye-glass upon the reticule in the beginning.* He will then obtain the same position of the reticule with respect to the object-glass for distances of one, five, or more hundred feet. Consequently, a stadia properly made for any particular object-glass or telescope, will never need any alteration whatever for different observers. These principles, as well as being in keeping with the principles of optics, I have entirely corroborated by actual experiment with a good stadia instrument.

Mr. Mayer states that the vertex of the visual angle is at the eye of the observer. Although this is sufficient for the approximate formulæ which he gives, yet strictly it is at the *object-glass* at an infinite number of points, but may be regarded as at its optical centre. The two planes of rays which proceed from the spider threads of the reticule, and intersect at the optical centre of the object-glass, exactly contain the visual angle on either side of the glass. Knowing this fact, and the focal length of the glass, it is easy to calculate the interval between the wires of the reticule for any given case, which is equal to the focal length multiplied by the tangent of the given visual angle.

In my previous article upon the stadia, I stated that in order to find the length of the divisions of the stadia, it was desirable to use a base of about 1000 feet, assuming 1500 as the maximum reading to be made in practice. But when it is the intention to use the approximate formulæ, the work will be more nearly correct by selecting a base line, the length of which shall be near a mean of the readings that may be taken in the field work. Since the reading of distances less than this base will be too small, and of distances greater than the base too large, it is probable that the plus and minus errors will nearly balance in long courses. But when it is designed to use the accurate formulæ of (21) and (22) of my article in the number referred to, the base may be taken at pleasure.

Methods for determining the heights and horizontal distances graphically from the field notes have already been explained. This diminishes greatly the time and trouble otherwise required without much injury to the accuracy of the work, if the diagrams are properly constructed.

The diagrams illustrated by Mr. Mayer for reduction to the horizon are very good, although I would suggest the use of vertical lines drawn to the horizontal scale, and both this and the vertical scale numbered with the proper numbers, divided by 10, 100, 1000, &c., if necessary; then the diagram will give directly the required quantity, without the use of a pair of dividers and a scale.

The quadrants which were described, answer a good purpose for getting the heights, but these require a pair of dividers and a scale. The plan of using triangles does not necessitate the use of any other

instrument. They were designed by myself for this purpose. Noting in the mind a reading of stadia, and the corresponding vertical angle, the height is at once traced out upon the triangle and given in the required numerical quantity. In my previous paper upon the stadia, in giving directions for the construction of these triangles, I made an error in stating that the lines drawn from the horizontal scale should intersect at the opposite angle of the triangle. They should be drawn parallel to each other. Specific directions for the construction of the triangles are given below.

Heretofore we have only considered the question of graphical computation as regarding the reduction of observations by these approximate formulas, viz:

$$x = \text{R} \cos^2 v, \text{ or } \text{R} - x = \text{R} \sin^2 v, \text{ and } y = \tfrac{1}{2} \text{R} \sin 2v.$$

But I now propose to show how diagrams can be obtained for graphical determination of the heights and distances in strict accordance with the accurate formulas (21) and (22) given in the February number. These diagrams once constructed, the labor required in their use is the same as that for diagrams made to the approximate formulæ, except adding a small quantity, nearly constant, depending upon $(c+f)$ attached to the diagram, a sacrifice which is small compared with the satisfaction of having the work reduced by correct principles. The correct formulæ (21) and (22) are

$$x = \text{R} \cos^2 v \left(1 - \frac{c+f}{x^1}\right) + (c+f) \cos v, \quad . \quad . \quad (21)$$

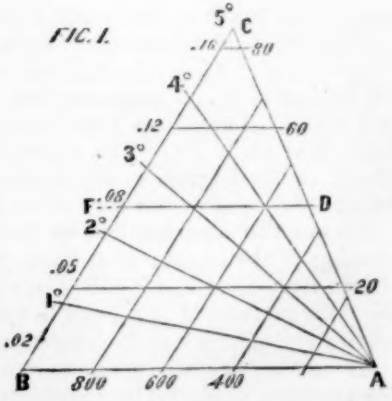
$$y = \tfrac{1}{2} \text{R} \sin 2v \left(1 - \frac{c+f}{x^1}\right) + (c+f) \sin v, \quad . \quad (22)$$

in which x is the horizontal distance required, y the required height, R the reading of the stadia, v the vertical angle, f the principal focal length of the object-glass, c the distance of the Y's from the object-glass, and x^1 the base line used in getting the dimensions of the stadia divisions.

These formulæ are correct for a stadia uniformly divided, unless the two parts of the visual angle, formed by the three spider threads of the reticule of the telescope are *very* unequal.

Now, let us suppose for a moment, the diagram scale A B C, Fig. 1, to be so constructed that the vertical scale, A C, gives the horizontal distances $= x = \text{R} \cos^2 v$, which corresponds with the approximate formula. This quantity may be computed and the number put in its proper place as at D in the vertical scale, which will be the required horizontal distance for all intersections on the line D F.

FIG. 1.



We notice that the first part of the second member of (21) is R $\cos^2 v$ $\left(1-\frac{c+f}{x^1}\right)$, which is the same as the approximate formula excepting the parenthetical quantity, which is always a constant fraction for the same stadia and instrument. Consequently, instead of R $\cos^2 v$ we should have a certain fractional part of it ($\frac{99}{100}$ for example) for every intersection on the line D F. Hence, if we put at D, $\frac{99}{100}$ of the quantity we had computed, we will have a diagram giving the correct amount corresponding to R $\cos^2 v \left(1-\frac{c+f}{x^1}\right)$ instead of R $\cos^2 v$.

What is true of one line, D F, of the vertical scale is true of all. The diagram thus far completed gives the first and most important part of the second member of (21). The second part, $(c+f)\cos v$, is small and varies but slightly for a change of a whole degree in v. Consequently, values of this may be calculated and put on the diagram, or in a table at one side of it. All that has been said of (21) is also true of (22).

Let us calculate some of the quantities and construct the skeleton of a diagram which shall give some of the values of y required by (22) to the first five degrees. Let us take $x^1 = 1000$; and as R may be any quantity let it be taken at 1000. Let $f = 1{\cdot}3$ and $c = 0{\cdot}7$. Then for $v = 5°$, $\frac{R}{2}\sin 2v\left(1-\frac{c+f}{x^1}\right) = 500 \sin 10° \left(1-\frac{2{\cdot}0}{1000}\right) = 86{\cdot}6+$.

Similarly if

$v = 1°$	$\frac{1}{2}$ R $\sin 2v\left(1-\frac{c+f}{x^1}\right)$		$= 17{\cdot}4$,	and	$(c+f \sin v$	$= {\cdot}03^{02}$
$v = 2°$	"	"	34·8	"	"	$0{\cdot}7^{05}$
$v = 3°$	"	"	52·2	"	"	$\cdot 10^{08}$
$v = 4°$	"	"	69·5	"	"	$\cdot 14^{12}$
$v = 5°$	"	"	86·6	"	"	$\cdot 17^{16}$

Now, draw A B and A C, Fig. 1, and take A B a scale of 1000 equal parts. Make a scale of equal parts on A C, and designate the tens by the proper numbers, and draw lines parallel to A B: and as we have designed to make 5° the upper limit, take the point c at 86·6 of the vertical scale, and draw B C. Then on B C at a point which shall correspond with 69·5 of the vertical scale, draw a line to A. This will be the line of 4°. Thus proceed until all the lines designating degrees are drawn. Draw lines parallel to B C from equidistant points of the horizontal scale A B. The quantities depending on $(c+f)$ may be placed in the diagram as represented. The diagram is now complete except that subdivisions may be made to any extent desired.

To use this diagram, find on the scale, A B, the number equal the reading of the stadia; then follow the line till it intersects with that drawn from A, expressing the number of degrees of the vertical angle. Note the position of this point in the vertical scale. Its height after adding $(c+f)$ sin v is the height required.

If one triangle will not contain a sufficient number of degrees, 25 for example, of the vertical angle without confusion of lines, the num-

ber of triangles can be increased. But in any triangle which does not begin with zero degrees, the lines of the vertical scale, A C, will not be parallel to A B. To show this more clearly, let us construct a diagram commencing with 10° and ending with 14°. Then for

$$v = 10°\ \tfrac{1}{2}\,\mathrm{R}\sin 2v\left(1-\frac{c+f}{x^1}\right) = 170{\cdot}7, \text{ and } (c+f)\sin v = {\cdot}35$$

$v = 11°$	"	"	186·9	"	"	·38
$v = 12°$	"	"	205·0	"	"	·42
$v = 13°$	"	"	218·8	"	"	·45
$v = 14°$	"	"	234·2	"	"	·48

Now, draw A B and A C, Fig. 2, and construct a scale of equal parts on each as before, A C containing 234·2 equal parts. Since the diagram must give 170·7 for R = 1000 and $v = 10°$, we will draw a line through B and 170·7 of the scale A C, parallel to which draw all the other lines of this scale. Then from the point of intersection of B C with a line through 186·9 of the vertical scale, draw a line to A. This is the line of 11°. Thus proceed to obtain the lines for 12°, 13°, &c. The quantities $(c+f)\sin v$ may be treated as before. I have only computed the quantities for the even degrees. Quantities for subdividing to any extent desired may be calculated in a similar manner. The lines I have supposed drawn from A C to B C for designating points on B C are only temporary or imaginary. It is better to draw permanent lines only at reguar intervals which can be numbered with integral numbers.

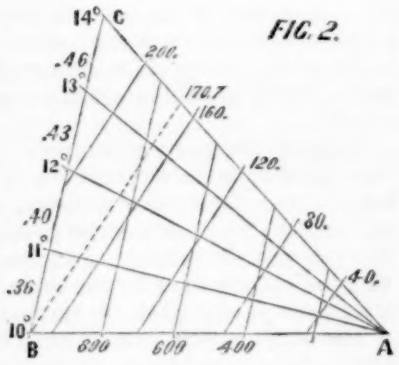


FIG. 2.

Diagrams for (21) can be constructed by following a course entirely similar to that pursued for (22).

These diagrams when once constructed for any particular instrument, can only be used with strict propriety for this or other instruments having the same distance intervening between the Y's and the object-glass, of which also the principal focal length is the same, or in which $(c+f)$ is the same, since this in the formulæ may be regarded as a single quantity. The errors in the use of these diagrams, however, will always prove to be less than if obtained from diagrams answering to the approximate formulæ $\mathrm{R}\cos^2 v$ and $\frac{\mathrm{R}}{2}\sin 2v$, except where $(c+f)$ for the instrument used is less than about half the value given it in making the diagrams. From this, in connexion with the fact that $(c+f)$ in all the ordinary stadia instruments used will never differ one-half, it appears that these diagrams are preferable to those adapted to the approximate formulæ.

Diagrams answering to the approximate formulæ, can be constructed in a *form* similar to that for (21) and (22).

To give good results the triangles should have eight or ten inches on a side.

The accuracy of the work which can be performed by the use of the stadia instrument is surprising. A fair trial is sufficient to remove all prejudice, if any exists. If it does exist, it must be in the idea of getting distances by sight. But if we inquire into the facts of the case, we find this to be a species of triangulation, the stadia being the base of a triangle in which all the angles are known. The visual angle being very much magnified, the power of measuring distances by it is magnified also. The only fear of great and unaccountable errors entering into the work must be chiefly from an apprehension of changes in the visual angle. Experience, however, shows that if the reticule be properly constructed, it cannot undergo appreciable changes. The redetermination of the delicate intervals of the reticules of astronomical transits proves their practical permanency.

For all the formulæ and diagrams considered in this article, the stadia should be held in a vertical position while taking observations upon it.

Some of the many advantages in the use of this instrument are that the data will always give both the heights and horizontal distances; and the vertical distance, easily gained by a single setting, will exceed ten times the rise possible to obtain by a leveling instrument at a single setting. In meandering rivers, lakes, &c., labor is saved of cutting lines for the chain; and it matters not so much what irregularities of surface are encountered.

The stadia and instrument are a substitute for the transit, the level, and the chain, and fewer assistants and men are required to accomplish the same amount of work, and, instead of its being in the hands of two or three, it may all be subject to the control of one observer.

It will be found to be a most economical and expeditious method of running preliminary lines for railroads, canals, laying water pipes, and for making topography, to which it is peculiarly adapted. It has advantages for locating points of interest in mining regions where there has been no land survey, and for furnishing data for geological maps and charts.

MECHANICS, PHYSICS, AND CHEMISTRY.

Incrustation of Steam Boilers.

From the London Mechanics' Magazine, March, 1865.

We have recently noticed corrosion as one of the ills to which the boiler is heir, and we will now consider another of a less insidious but not less dangerous nature, viz: incrustation. This evil is too frequently regarded merely as a matter of inconvenience, or, at the most, as a nuisance of which the owners of boilers would be very glad to be

relieved. But this is a false light in which to view it, for it is a source of positive danger, and not unfrequently the cause of steam boiler explosions. Witness the facts of a recent colliery boiler explosion. Here was a plain cylindrical egg-end boiler, 40 ft. long by 5 ft. 3 ins. diameter, made of $\frac{3}{8}$ths in. plates, and working at a pressure of 30 lbs. per square inch. It was fitted with two sufficient safety valves and two floats, one of them having a lower water alarm whistle. The plates over the furnace became overheated, and the boiler was rent in four pieces. There was no evidence of a deficiency of water, but the cause of the overheating was attributable simply to the sedimentary character of the water. The number of boilers which suffer from incrustation is very large; indeed, to find one that does not is quite exceptional. It impedes the satisfactory examination of a boiler, inasmuch as it renders it difficult to ascertain the precise condition of the plates. It sometimes deludes by awakening groundless suspicions of corrosion; more frequently, however, it conceals defects, for it is often found that corrosion is stealthily going on under the deposit which is causing it. A great waste of fuel is one of the evils resulting from incrustation; in addition to this, and apart from overheating, there must be a considerable increase in the wear and tear of boilers. In internally double-flued boilers, the undue longitudinal expansion given to the furnace crowns increases the tendency to groove at the front end plate. In these boilers this action is always present to a greater or less extent. In localities where good water is not to be had, incrustation renders the adoption of tubular boilers impracticable, thus excluding this economical class of boiler from more general use. But the injurious effects of water which will cause incrustation are not always limited to the boiler. The steam carries over a considerable quantity of earthy matter into the engines, and so necessitates an increased amount of grease for the piston and slides. As an illustration of this fact it may be noticed that, where the feed water of boilers is taken from brooks subject to torrents which stir up the mud, the engine-men find the pistons and slides clog if they neglect the precautionary measure of extra lubrication.

The causes of incrustation do not lie very deeply hidden; it is, therefore, but a simple matter to determine them, existing as they do in the water with which the boiler is supplied. Carbonate and sulphate of lime form the principal constituents of water. The carbonate in precipitating forms a loose powder, but the sulphate a hard crust. Both together will also form a solid incrustation more or less hard in proportion as the one or the other of the salts predominates. This deposit, when allowed to accumulate, forms a hard scale which adheres very tenaciously to the iron, and is troublesome to remove. There is, no doubt, much difficulty experienced by the owners of boilers in judging of the quality of the water they have to use, but it is always open to them to have a chemical analysis made; and this is often essential when there are two or more sources of supply in the same locality, as the water, although apparently obtained from the same primary source, may differ very greatly in its composition at two different points. There

is an instance of this in a well which produced almost pure water containing an alkali but no lime. From this well a boiler was supplied for many years without any incrustation having been formed, the boiler being cleaned by simply brushing out. Within half a mile of this well another was sunk, but which yielded water containing so large a proportion of lime that in a few weeks a thick incrustation was formed within the boiler fed with it. Both wells were sunk through London clay into the chalk. It is a fallacy to attempt to estimate water from its appearance; transparency does not always mean purity. A specimen of water of perfect apparent purity taken from a London pump, gave, on testing, 140 grains of different kinds of salts per gallon of water, whilst a sample taken from the Thames—considered bad enough—yielded, at the most, 20 grains of salts per gallon tested.

Of the preventions and remedies which have been proposed from time to time, it may be said their name is legion; they form the subject of a goodly number of patents. Among the preventives are various methods of filtration and purification by chemical processes, whilst the remedies consist chiefly of a variety of compounds best known as "boiler compositions." Both these find supporters and objectors, and this arises from the fact that there are instances in which, either from accident or a judicious choice, selection is made of a remedy which proves suitable to the disease, whilst, on the other hand, an improper antidote is very often applied, it being frequently supposed that one description of boiler fluid, or other scale preventer, is applicable in all cases. Where water is found to form a rapid incrustation, it should be submitted to chemical analysis, the result of which would indicate the proper remedy. Apart from the doctoring processes, are several simple and inexpensive remedies which have proved very effective in preventing incrustation. One of these consists in placing small logs of oak, with the bark on, in the boiler, which has the effect of reducing the carbonate of lime to a kind of sludge, which falls to the bottom and thus preserves the boiler perfectly clean. This plan has been pursued by one of the London water companies for many years with perfect success. Mahogany sawdust has been employed with advantage for the same purpose as the oak logs. It acts in two ways—first, mechanically, by offering so many small points on which the carbonate and sulphate of lime may be deposited; and, secondly, by a peculiar action of the extractive matter in the wood. This applies more particularly to oak, especially when green, in which state it should be used. In North Wales the water used in boilers is often perfectly green, and oak sawdust is administered in considerable quantities. Chloride of ammonium will convert the lime salts into soluble compounds, viz: sulphate and carbonate of ammonia, and chloride of calcium; but in practice its use has not been very successful, owing to the sal ammoniac and ammoniacal salts acting on the brass-work. Where the action of a cure is only partial, as is the case with some boiler fluids, the remedy is worse than the disease. For instance, in some boilers at Woolwich supplied with Thames water, a certain composition was used in the hope of preventing incrustation. It was found that the composition

only acted upon the lighter portion of the sediment, leaving untouched the heavier and harder portion, which, though forming a much thinner deposit, was nevertheless impenetrable to the water, whilst, on leaving the lighter and heavier ingredients undisturbed, they were found to form a porous substance through which the water could reach the plates.

There can, of course, be no legitimate objection to the adoption of a remedy when a disease has been contracted, provided the remedy be appropriate. When the human system becomes deranged, recourse is had to medical aid. But a man of regular habit with an originally good constitution rarely requires the doctor. So with steam boilers—a well constructed boiler, with attention, need never be troubled with incrustation, except in rare instances. Prevention is at all times better than cure, and under all circumstances, where the construction of the boiler does not insure immunity, the most practical plan for the prevention of incrustation is the adoption of an efficient mode for blowing out. A more complete remedy, however, exists in the adoption of what is termed dry or surface condensation. But the benefits to be derived from judicious blowing-out are not generally realized, or there would not be the irregularity there is in the use of the blow-out apparatus. To be effectual in its operation it should be used at regular intervals during the day, the best time being whenever the engine is not at work and the water therefore at rest. Under these conditions the sediment has an opportunity of settling, whereas, at other times, it will be held in suspension by the rising bubbles of steam, when blowing-out will be comparatively useless. But, however regularly the operation may be performed, it cannot be effectual if confined to one point only in the boiler, when there is a heavy sediment. But the action may be distributed throughout the whole length of the boiler by having a perforated pipe carried from end to end. There are other ways by which the same result may be attained, but this arrangement has been found to answer the purpose exceedingly well. It sometimes happens that the lighter sediment will elude this apparatus, and will settle on the plates of the flues and shell. In such cases, by the use of scum pipes, it may be blown out whilst floating on the top of the water as scum, before it has time to adhere. The adoption of these pipes is the common practice in marine boilers, and might be judiciously applied to land boilers. It is a noticeable fact, although one not generally recognized, that overheating often occurs where no actual cake of deposit is formed. In many cases this may be due to the presence of thickening matter held in suspension in the water. Where the circulation is imperfect, or where there is no agitation, such as in a locomotive when running, the impediment presented by the sedimentary matter to the free escape of steam, doubtless lifts the water off the plates and so causes overheating. Instances are constantly occurring where overheating takes place with an ample supply of water, and where no incrustation is formed, such cases being chiefly confined to externally fired boilers.

A singular case of grease incrustation resulting in an explosion is

given by Mr. Longridge, the engineer of Steam Boiler Assurance Company in his last report. The case is worth noticing because it proves beyond doubt that explosions do occur from a cause which is little believed in. The boiler referred to was cylindrical, with hemispherical ends, made of ⅜-in. plates, in 1850, and had 2½-in. safety valves, weighted to blow off at 40 lbs. One day in last October, about noon, a loud report was heard, and the fireman was thrown down, steam and water issuing from the fire door at the same instant. On examination, it was found that about 8 ft. beyond the bridge there was a hole in one end of the plates of an irregular triangular form about 7 ins. in length, and 4 ins. in width at the base. Around the hole in the inside was an accumulation of deposit extending over an area of about 2½ square feet, from 1 in. to 1¼ in. thick in the centre, and gradually reduced in thickness towards the outside. In other parts the boiler was almost free from deposit, but the surface of the plates had a greasy appearance, and at the back end there was a small patch of deposit of the same kind as that just mentioned. The deposit was found to be composed of grease and earthy matters, and on applying a light it ignited like a piece of wood. The formation of this deposit is due to the introduction of grease either by the attendant or in the feed water, which, it appears, at times conveyed greasy matter from soap works. The feed pipe delivered the water about fifteen inches from the centre of the hole in the plate on the side nearest the fire, and 10 ins. from the bottom of the boiler; the feed had been turned on about ten minutes previous to the accident, and the plate showed evidence of its cooling effect on that side. The conclusion is that, after the plate had become red hot, in consequence of the deposit, the latter had become loosened, and fracture taking place, water had intervened between the deposit and plate, producing a sudden generation of steam sufficient to cause rupture. It is a common practice to throw into boilers, old greasy cotton waste under the impression that it facilitates the removal of scale. But it is open to objection, inasmuch as the oil combines with impurities in the water and forms a greasy substance, which, when precipitated on the plates, prevents contact of the water and is thus the cause of overheating. It has, however, been found greatly to facilitate the cleaning of boilers if the plates were greased after every cleaning. For this purpose, in the royal gun factories at Woolwich, the refuse oil from the drip cans of the shafting is collected, and, after the boilers are cleaned, it is laid on inside them with a brush. Although this does not stop the incrustation it causes it to come off the plates much more readily, and is found to effect a great saving in time and expense in cleaning the boilers.

A simple method of depriving water of its earthy carbonates was successfully adopted in a small high pressure boiler. This was done by admitting a very small jet of cold water into the exhaust pipe of the engine, where, mingling with the waste steam, it condensed a portion of it. The steam, by raising the water to a boiling heat, drove off the free carbonic acid, and the neutral carbonates were thrown down on the sides of the pipe, which was made large enough to allow

it to accumulate. The water then ran down into a tank, whence it was pumped into the boiler at a temperature of about 200°. In addition to this, the partial condensation of the waste steam reduced the back pressure on the piston, and the result was a saving of half the fuel, the boiler remaining quite free from scale. But better than all these is the plan of using boilers properly constructed in the first instance, by which incrustation is reduced to a minimum, if not entirely prevented. By a properly constructed boiler is meant one so arranged that a proper circulation of the water is effected. In boilers thus designed such a thing as scaling is of very rare occurrence. Some eight and twenty years ago, a small circular boiler with water tubes was made by Mr. Hugh Greaves, we believe, the first of its kind in this country. Between the fire box and the outer case was placed a piece of sheet iron around the fire box and the tubes, by which means the circulation was completely established. After being in use twelve years the boiler was taken to pieces, and the fire box was scarcely coated, and the slight incrustation was clearly of very recent formation. In the Benson boiler, when worked with salt water, at high pressures, no incrustation takes place, owing to the rapid circulation of the water. The Field boiler, described in our number for February 17th, is another in which the principle of rapid circulation is fully developed and incrustation consequently prevented. In the Harrison or multispherical boiler this latter condition is secured by two-fold means, a double action being at work to hinder the formation of scale—first, the perfect circulation, and if that be insufficient, second, the alternate action of expansion and contraction. Scale being deposited whilst the spheres were heated, would, on their cooling and consequent contraction be broken up and thrown down. In marine boilers, incrustation was, at one time, a perplexing matter to deal with, as it was supposed to be impossible to prevent the boilers of a steamer from becoming salted up in some seas. But it has been ascertained that the saltness of different seas varies but little, and however salt the water may be, the boiler can be preserved from any injurious amount of incrustation by blowing out as already noticed. This operation, to be effectual, should be performed very frequently, or a portion of the super-salted water may occasionally be allowed to escape. But, by proper blowing out, a very slight scale, at the most, will ever be found. There is no excuse for the engineer who allows his boiler to become damaged from incrustation.

For the Journal of the Franklin Institute.

A Body has no Weight while Falling freely by Gravity.

Gravity acts upon a body in an uninterrupted stream of force. While the body is at rest, this stream is incessantly entering, pervading, and *leaving* it. In doing this last, the force is as incessantly being destroyed by being equilibrated, or reacted against, by the equal op-

posing force of compression or of tension inherent in whatever other body keeps it at rest. This reaction of two forces is always attended by strain; that is, by either pushing or pulling; and in the case of a body at rest, the vertical *strain* which gravity produces, is called its *weight*.

But when a body begins to fall freely, or unresistedly, it instantly becomes converted as it were into a reservoir, into which all this stream of gravity becomes stored-up or accumulated, instead of being lost or destroyed as before. This stored-up force now becomes *motion* alone, without any strain, inasmuch as there is now no opposing force for it to strain or react against. Consequently, the body moves faster and faster, as the quantity of stored-up force gradually becomes greater.

This quantity of force, or, in other words, the quantity of force which produces motion in a given body, is directly proportionate to the velocity of the body; and since in a body falling freely *all* the force produces velocity alone without strain, the velocity becomes an absolute measure of the proportionate total quantities of force in it at different stages of its fall.

A body so falling for one second acquires a velocity of 32·2 feet per second; and at the end of two seconds, a velocity of 64·4 feet per second. Consequently, by the end of two seconds, there is stored up in it exactly twice as much force of gravity as at the end of the first second; and so on, according to the number of seconds. But if from the beginning of its fall the body retained stored up in it that increment of gravity also which had *previously* constituted its *weight*, this proportionality could not possibly exist; for at the end of the first second, the quantity of gravity in the body would be the sum of the weight and of the gravity accumulated during that second; and at the end of the second second, it would be the sum of the weight and of the gravity accumulated during two seconds; and the last of these sums would not be twice as great as the first. There is, therefore, no gravity in a body falling freely except that which enters it from the moment it begins to fall.

All the gravity in a body may exhibit itself either as weight or as motion, but not as both of these at the same time; for the same identical increments of force can never produce both strain and motion at the same time. Therefore, the quantity which produces the strain called weight, cannot at the same time produce motion; nor can it while producing motion, produce weight also.

To a person at all conversant with the subject, the foregoing will of course appear to be nothing more than a useless play upon words, and in deference to the opinions of such persons, the writer would not have presented them. But inasmuch as the *Journal* is read by many purely practical men who find it difficult to divest themselves of the idea that there is in a falling body, a certain inherent property called weight, which assists gravity by some kind of pushing process in expediting its fall, he was induced to offer these remarks for their consideration alone. J.

Action of Sea Water on Metals. By F. Crace Calvert, Ph.D., F.R.S., and R. Johnson, F.C.S.

From the London Mechanics' Magazine, March, 1865.

We were induced to examine the action exerted by sea water in consequence of the rapid changes which have taken place of late years in naval architecture, and especially in the substitution of metals and alloys for wood. To carry out the above views, we took twenty square centimetres of each metal, which we cleaned with great care and attention in order that the action of sea water might have its full effect; then two plates of each metal were placed in separate glass vessels, and immersed in equal volumes of sea water. After one month the plates were taken out, and any compounds that had adhered to the surface carefully removed; the plates were then dried and re-weighed, and the loss estimated. To render our results of more practical value, we have calculated the action of one hundred litres of sea water upon one square metre of each metal, and the following are the amounts in grammes of metals dissolved: steel, 29·16; iron, 27·37; copper, (best selected,) 12·96; copper, (rough cake,) 13·85; zinc, 5·66; galvanized iron, 1·12; block tin, 1·55; stream tin, 1·45; lead, (virgin,) trace; lead, (common,) trace. These results appear to us to lead to the following conclusions: 1. That the metal now most in vogue for shipbuilding, namely, iron, is that which is most readily attacked. 2. That this metal is most materially preserved from the action of sea water when coated with zinc, and, therefore, in our opinion, it would amply repay shipbuilders to use galvanized iron as a substitute for that metal itself. The above facts perfectly confirm those which we have already published in our paper, "On Galvanized Iron for Armor Plated Ships," in which it was shown, that when iron was in contact with oak they mutually acted upon each other, producing a rapid destruction of the two materials, whilst little or no action took place between galvanized iron and the wood. 3. The extraordinary resistance which lead offers to the action of sea water naturally suggests its use as a preservative to iron vessels against the destructive action of that element; and, although we are aware that pure lead is too soft to withstand the wear and tear which ships bottoms are subject to, still we feel that an alloy of lead could be devised which would meet the requirements of shipbuilders. Feeling that experiments made with a limited amount of sea water might not be a fair criterion of the action of the ocean upon metals, we repeated our experiments upon plates of forty centimetres square, which were immersed for one month in the sea on the western coast, (Fleetwood,) taking the precaution that they should be constantly beneath the surface of the water, and suspended by flax rope attached to a wooden structure, to prevent any galvanic action taking place between the plates and the structure to which they were attached. The following are the amounts in grammes of metals dissolved: steel, 105·31; iron, 99·30; copper, (best selected,) 29·72; zinc, 34·34; galvanized iron, 14·42; lead, (virgin,) 25·69; lead, (common,) 25·85. The above figures suggest the following remarks: That the action has

been much more intense, in this instance, than when the metals were placed in a limited amount of water in the laboratory. These results are due probably to several causes acting at the same time, viz: that the metal was exposed to the constantly renewing surface of an active agent; and there was also a considerable friction exerted on the surface of the plate by the constant motion of the water, there being at Fleetwood, a powerful tide and rough seas. What substantiates this opinion is, that the lead plates undoubtedly lost the greater part of the weight, not by the solvent action of the sea water, but from particles of lead detached from them, in consequence of their coming in contact with sand and the wooden supports to which they were attached; but this cause of destruction having been observed with lead plates, it was afterwards carefully guarded against in the case of all the other metal plates.

We also deemed it desirable to examine the action of sea water on various brasses. We therefore immersed for one month, plates of various alloys in that fluid, and the following are the results of the action of two hundred litres of sea water upon one square metre surface of the following brasses:

Composition of Brasses.		*Quality of Metals Dissolved.*			
		IRON.	COPPER.	ZINC.	TOTAL.
Pure copper, . .	50·0				
Pure zinc, . .	50·0				
	100·0	——	1·110	10·537	11·647
Commercial brass:					
Copper, . . .	66·0				
Zinc, . . .	32·5				
Iron and lead, .	1·5				
	100·0	0·579	3·667	3·324	7·570
Muntz metal, (sheet):					
Copper, . . .	70·0				
Zinc, . . .	29·2				
Iron and lead, .	0·8				
	100·0	0·438	4·226	2·721	7·385
Muntz metal, (bars):					
Copper, . . .	62·0				
Zinc, . . .	37·0				
Lead and iron, .	1·0				
	100·0	0·501	2·697	3·493	6·691
Prepared brass:					
Copper, . . .	50·0				
Zinc, . . .	48·0				
Tin. . . .	2·0	TIN.			
	100·0	0·365	7·04	3·477	10·882

These results show how very differently sea water acts upon divers brasses and the influence exercised upon the copper and zinc composing them by the existence in them of a very small proportion of another metal; thus, in pure brass the zinc is most rapidly dissolved, (which, *en passant*, is the contrary to what takes place in galvanized iron,) whilst it acts as a preservative to the copper. Tin, on the other hand, appears to preserve the zinc, but to assist the action of sea

water upon the copper. The great difference between the action of sea water upon pure copper and upon Muntz metal seems to us to be due not only to the fact that copper is alloyed to zinc, but to the small proportion of lead and iron which that alloy contains; and there can be no doubt that shipbuilders derive great benefit by using it for the keels of their vessels.

We were so surprised at the inaction of sea water upon lead, that we are induced to compare its action with that of several distinct varieties of water, viz: Manchester Corporation water—well water—distilled water in contact with air—the same deprived of air; and the following are the amounts of metal dissolved by two hundred litres of these waters upon one square metre of surface during eight weeks; the amounts are given in grammes. Manchester Corporation water, 2·094; well water, 1·477; distilled water, (with air,) 110·003; distilled water, (without air,) 1·829; sea water, 0·038. These figures require no comment, as they confirm our previous result that sea water has no action on lead.

Mr. John Robinson exhibited specimens of iron and brass which had been acted upon by the water of the river Medlock, and stated he had found that an alloy of lead, tin, and antimony resisted the action of sea water better than any other metal or alloy he had tried.

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.

From the London Chemical News, No. 249.

(Continued from vol. I., page 406.)

Lecture VI.

Flesh, its chief constituents, boiling and roasting. *Animal black*, its manufacture and applications. Various methods of preserving animal matters. Employment of animal refuse in the manufacture of *prussiate of potash*. A few words on the decay of organic matters, and their fermentation and putrefaction.

It will be easily understood by those who have done me the honor of attending this course, that this last lecture must touch upon a variety of topics, in order to give an idea of some of the applications which animal matters receive, and which yet remain to be discussed.

Flesh.—M. Chevreul, in 1835, and Baron Liebig, in 1845, examined the changes which flesh undergoes when placed in contact with hot and cold water; and the following table, taken from Liebig's interesting work on the chemistry of food, will give you an idea of the composition of flesh:

Cold water.		Action of boiling.	
Soluble,	66	Coagulated albumen,	29·5
		Gelatine,	6·0
		In solution,	30·5
Insoluble,	161	Fibres and membranes,	164·0
Fat,	20		
Water,	750		
	1000		

Liebig and Chevreul further succeeded in isolating, of the 30 parts soluble in water, some of the following substances:

Kreatine,	$C_8\ H_9\ N_3\ O_4 + 2\,H\,O$
Kreatinine,	$C_8\ H_7\ N_3\ O_2$
Sarcosine,	$C_6\ H_7\ N_1\ O_4$
Inosinic acid,	$C_{10}\ H_6\ N_2\ O_{10} + H\,O$
Lactic acid,	$C_6\ H_5\ O_5$
Guanine [Scherer],	$C_{10}\ H_5\ N_5\ O_2$
Xanthine [Strecher],	$C_{10}\ H_4\ N_4\ O_4$
Glycocoll,	$C_4\ H_5\ N\ O_4$
Leucine,	$C_{12}\ H_{13}\ N\ O_4$
Osmazome,	

The most important mineral salts in flesh are the acid phosphate and lactate of lime, and, according to Fremy, the acid phosphate of potash and chloride of potassium. The above statement shows that flesh is a most complicated substance, and it is easy to conceive that this must be so, when it is remembered that it is derived from blood, of which it contains a large amount; but a most interesting and curious fact is, that whilst blood is rich in salts of soda and poor in salts of potash, in flesh the relative proportion of these salts is directly reversed. Another interesting fact is the small amount of solid matter contained in flesh, and also the small amount of nutritive matter it yields to water under the most favorable circumstances. I repeat "the most favorable circumstances," for when meat is placed in boiling water, the 3 per cent. of albumen it contains is coagulated, closing the vessels of the flesh, and preventing all further exit of the fleshy fluids, and such should be the case when meat is intended to be eaten as boiled meat, and is properly cooked; but when the object in view is to extract the whole of the matter soluble in water, as in the preparation of beef tea, then the meat should be cut in small pieces, and brayed in a mortar with water, the whole then thrown into clean linen and pressed. The juice of the flesh so obtained should then be carried just to the boil, again passed through the strainer, and, after the addition of a little common salt, will be ready for the patient. Beef tea, even prepared by this process, which is certainly the best to my knowledge, contains, as the table above shows, but a small quantity of nutritive matter, there being only a little gelatine and a small proportion of the other substances named above. Chevreul attributes the odor of beef tea and meat soups to osmazome, and Liebig to kreatine; in fact, Liebig considers kreatine to be one of the essential substances characterising the aroma of various kinds of flesh. Liebig, during his researches on this substance, succeeded in obtaining from

Fowls' flesh,	3·21 of kreatine.
Ox heart,	1·37 "
Pigeon,	0·82 "
Beef,	0·69 "

Further, he observed, that the flesh of wild animals contained a much larger proportion of kreatine than those which were confined; for instance, that there was six times as much in the flesh of a wild fox as in that of a tame one. Allow me to say a few words on the properties of this curious substance, which presents itself in the form of mode-

rately large white rectangular prisms, having a pearly lustre, soluble in water, insoluble in alcohol; and although this substance is neutral, it is converted, when heated with hydrochloric acid, into another solid crystallized substance called kreatinine, which possesses strong alkaline properties. When kreatine, instead of being treated by an acid is acted upon by baryta, it is converted into an acid compound called inosinic acid. Liebig ultimately succeeded in finding these substances, as well as another called sarcosine, in various animal secretions. I shall not take up more of your time by discussing the chemical properties of these substances, but merely state that they enable us to distinguish real soup tablets from spurious ones. For this purpose a solution of the tablet in cold water should be made, when, if genuine, it will give a precipitate with chloride of zinc, whilst the spurious one, which contains gelatine but no kreatine, will not do so. Another reaction is, that the pure article will yield 85 per cent. of its weight to alcohol, whilst the imitation will only yield about five.

Preservation of meat and animal substances.—A low temperature is most favorable to the preservation of flesh and other animal substances; it will not enter into putrefaction, the best proof of which is that elephants in a perfect state of conservation have been found in Siberia, buried in ice, where they have doubtless existed for many thousands of years. It is also well known that the inhabitants of polar regions preserve their meat fresh by burying it in snow, and I mentioned an instance in one of my previous lectures, viz: the preservation and bleaching of sturgeons' bladders on the banks of the Volga. A high state of dessication or dryness, also contributes powerfully to the prevention of decay. Thus in Buenos Ayres and Monte Video, meat is cut into thin slices, covered with maize flour, dried in the sun, and consumed largely, under the name of tassago or charke, by the inhabitants of the interior, and also by the black population in Brazil and the West Indies. Further, dried meat reduced to powder is used by travelers in Tartary and adjacent countries, and I may add, that of late years, meat biscuits have been extensively consumed by the emigrants having to travel from the United States to California, and the West Coast generally. It is stated that six ounces per diem of this meat biscuit will maintain a man in good health throughout the journey. A remarkable instance of the preservation of animal matter by extreme dessication is related by Dr. Wefer, who states that in 1787, during a journey in Peru, he found on the borders of the sea, many hundreds of corpses slightly buried in the sand, which, though they had evidently remained there for two or three centuries were perfectly dry and free from putrefaction. Although it is not within the scope of these lectures to describe the preservation of vegetable matters, still, I cannot refrain from mentioning the interesting method adopted by MM. Massan and Gannal, by which, as you are doubtless aware, vegetables are preserved in the most perfect manner. The process is most simple, as it consists in submitting the vegetables for a few minutes to the action of high pressure steam, (70 lbs. to the square inch,) then drying them by air heated to 100°, when, after compression by

hydraulic pressure, they are made into tablets for sale, and when required for use it is only necessary to place the tablets for five hours in cold water, when the vegetable substances swell out to their former size and appearance and are ready for cooking. As the presence of oxygen or air is an essential condition of putrefaction, the consequence is that many methods have been invented to exclude that agent, or rather, as I shall show at the end of this lecture, the sporules or germs of cryptogamic plants or animals, which are the true ferments or microscopic source of fermentation and putrefaction. Permit me to describe concisely some of the methods proposed, and I believe that one of the best processes for excluding air was that invented by Appert, in 1804. It consists in introducing the meat or other animal substance with some water into vessels which are nearly closed; these are then placed in a large boiler with salt, (which raises the boiling point of the liquor,) and the contents of the vessels are kept boiling for about an hour, so as to exclude all air, and destroy, by the high temperature, all the sporules or germs of putrefaction they may contain, when they are hermetically closed. M. Chevalier Appert has improved this process in placing the prepared vessels in a closed boiler, by which means he raises the temperature (by pressure) to 234°, which effects the same purpose more rapidly and economically. To give you an idea of the extent of this trade, I may state that M. Chevalier Appert prepared above 500,000 lbs. of meat for the French Army in the Crimea. I am aware that many modifications have been applied to this process, but I shall only mention that of Mr. G. M'Call, who adds to the previous principle of preservation a small quantity of sulphite of soda, well known to be a powerful antiseptic. The beautiful specimens now on the table, which have been kindly lent to me, by Messrs. Fortnum and Mason, and by Mr. M'Call, will satisfy you of the applicability of the above named methods for the preservation of meat and other animal substances. But before concluding this part of my lecture, I must add that the preservation of animal and vegetable substances by the exclusion of air and cryptogamic sporules is also effected by other methods than those above described; for instance, they are imbedded in oil, or in glycerine, as suggested by Mr. G. Wilson, or into saccharine syrups. I should not forget to mention that several plans have been proposed for protecting animal matter by covering their external surfaces with coatings impermeable to air. Two of the most recent are the following: M. Pelletier has proposed to cover the animal matter with a layer of gum, then immersing it in acetate of alumina, and lastly, in a solution of gelatine, allowing the whole to dry on the surface of the animal matter. The characteristic of this method is the use of acetate of alumina, which is not only a powerful antiseptic, but also forms an insoluble compound with gelatine, thus protecting the animal matter from external injury. Mr. Pagliari has lately introduced a method which is stated to give very good results. It consists in boiling benzoin resin in a solution of alum, immersing the animal matter in the solution, and driving off the excess of moisture by a current of hot air, which leaves the above antiseptics on the animal

matter. It is scarcely necessary to mention the old method of using smoke arising from the combustion of various kinds of wood, except to state that in this case it is the creosote and pyroligneous acid which are the preservative agents. The preservation of animal matter by a very similar action is effected by the use of carbolic acid a product obtained from coal tar. It is much to be regretted that this substance, which is the most powerful antiseptic known, cannot be made available for the preservation of organic substances intended for use in arts and manufactures; no cheaper or more effective material can be found. For example, I have ascertained that one part of carbolic acid added to five thousand parts of a strong solution of glue will keep it perfectly sweet for at least two years, and probably for an indefinite period. Also, if hides or skins are immersed for twenty-four hours in a solution of one part of carbolic acid to fifty of water, and then dried in the air, they will remain quite sweet. In fact, hides and bones so prepared have been safely imported from Monte Video. From these facts and many others, with which I am acquainted, I firmly believe that this substance is destined, within a few years, to be largely used as an antiseptic and disinfectant. I need hardly speak of the power of chloride of sodium, or common salt, in preserving animal matters, and it is highly probable that the interesting process described to you on the 13th April, by Mr. J. Morgan, for the employment of salt, is likely to render great service in preserving animal food from putrefaction. But with regard to the feasibility of its use in Monte Video and Buenos Ayres, I cannot offer an opinion, as it depends upon so many local circumstances which it is impossible to appreciate here. Messrs. Jones and Trevethick, displayed at the last Exhibition, some meat, fowls, and game preserved by the following process, which received the approbation of the jurors. Meat is placed in a tin canister, which is then hermetically closed, with the exception of two small apertures in the lid. It is then plunged into a vessel containing water, and after the air has been exhausted through one aperture by means of an air pump, nitrogen is admitted through the second aperture, and the alternate action of exhausting the air and replenishing the nitrogen is kept up until the whole of the air has been removed. The nitrogen in its turn is exhausted, and sulphurous acid gas admitted. The two apertures are then soldered up, and the operation is completed. As I consider the action of carbon on animal matters rather as a case of oxydation than of preservation, I shall refer to that subject further on, and shall, therefore, proceed to consider the employment of certain animal matters not yet alluded to during this course of lectures, such as the flesh of dead animals not used as food, and those other parts of their carcasses which have not been applied in any of the processes already described. The greatest part of these refuse matters are used for producing animal black, which differs from bone black, referred to in my first lecture, being used in the state of impalpable powder, whilst bone black or char is composed of small hard grains. The manufacture of animal black is generally carried out by introducing into horizontal retorts connected with a coil or condenser, and with an exit

pipe for the gases, some of the animal matters mentioned; on the application of heat, decomposition occurs, the oily matters distil and condense in the worm, and constitute what is called Dippel's oil formerly much used in the art of currying certain classes of leather; water also distils, charged with a variety of ammoniacal salts, which are generally converted into sulphate of ammonia for agricultural purposes. As to the gases, they are usually ignited and burnt to waste. The carbonaceous mass which remains in the retort is removed, and ground to powder in a mill with water, and allowed to settle, and, lastly, dried and sold under the name of animal black. Its chief uses are in the manufacture of blacking and printing ink. Another manufacture which consumes a large quantity of animal refuse especially the horns, hoofs, &c., of too inferior a quality to be used for the purposes described in my first lecture, is that of the yellow prussiate of potash, a most important salt, for it is extensively used in calico printing, silk and wool dyeing, and in the manufacture of the pigment called prussian blue, for gilding silver, copper, and other inferior metals; and, lastly, it is the source from which cyanide of potassium is procured, a substance much employed in the art of photography. Let me now call your attention to the manufacture of prussiate of potash, the greatest portion of which is prepared at the present day, still by the old process devised by Dr. Woodward, F.R.S., in 1724. It consists in introducing into cast iron pots, American pearlash, melting it, closing the vessel, and then setting the mass in motion by means of a revolving shaft. At this period of the operation, hoofs, horns, and other animal refuse, are introduced in small quantities at a time. Under the influence of heat and of the alkali, the nitrogen of the organic matters splits into two parts, one part combining with the hydrogen to form ammonia, which escapes, whilst the other portion unites with the carbon, producing cyanogen, which remains combined with the potassium of the potash. After several hours the operation is considered to be completed, and the melted mass is run out into small cast iron receptacles; when cool these are placed in large vats with water, and a jet of steam is introduced, and the whole is kept on the boil for several hours, when the cyanide of potassium is partly decomposed, giving rise to carbonate of potash and to cyanide of iron, for not only has a portion of the iron of the melting pots been attacked and combined with the mass, but a certain quantity of iron filings have been used during the operation. However, two parts of the cyanide of potassium combine with one part of cyanide of iron, and the result is that a double cyanide, called ferrocyanide of potassium, or yellow prussiate of potash, is formed. The liquors are then allowed to clear by standing, and the aqueous solution is evaporated until a pellicle appears on its surface, when it is allowed to cool, and the salt is deposited on strings which have been passed through the crystallizing vat, and which facilitate the crystallization of the prussiate salt. In consequence of the large amount of animal matter used as compared with the quantity of prussiate obtained, this salt has always commanded a good price in the market, and has induced many eminent

chemists to try to devise cheaper processes for obtaining it. To attempt here to give merely an outline of these various proposed plans would involve so much technical description as would occupy far too much time for this lecture, but I would recommend those interested in this branch of manufacture to read the learned account given by Dr. A. W. Hofmann, in his report on "The Chemical Products in the last Exhibition," page 57, where they will find the process of M. Gauthier-Bouchard for obtaining salts of cyanogen from the ammoniacal waters of gas works; those of Mr. R. T. Hughes and Messrs. Bramwell, of Newcastle, for the conversion of nitrogen of the atmosphere into cyanide of potassium; that of M. Kamrodt, for decomposing ammonia to carbon carried to a high temperature; and, lastly, that of MM. Margueritte, and De Sourdeval, for producing cyanogen from the nitrogen of the atmosphere and fixing it by means of barium. This latter process seems to be highly commended by the learned reporter to whom I have referred. I must not, however, omit to mention the scientific and interesting process devised by M. Gelis, and based on the chemical reaction which ensues when bisulphide of carbon is mixed with sulphide of ammonium. Yellow prussiate crystalizes in large crystals belonging to the octohedral system, composed, as before stated, of two parts of cyanide of potassium, 2CyK, and one of iron, CyFe + 3 of water or HO. This salt is freely soluble in water but is insoluble in alcohol, and when mixed with weak vitriol and heated gives rise to prussic acid, which distils, and may be used as a violent poison, or, in qualified hands, as a most valuable therapeutic agent. When ferrocyanide of potassium is heated with several times its bulk of concentrated sulphuric acid, instead of yielding prussic acid, as above, it gives rise to a poisonous gas, called oxide of carbon, which burns with a beautiful blue flame, and which we have all seen burning in some fireplaces when the combustible matter has lost all its volatile constituents and nothing remains but a red incandescent mass. When chlorine is passed through a solution of this salt chloride of potassium is formed, and the yellow prussiate is converted into red prussiate or ferricyanide of potassium, composed of $3CyK + 3Fe_2Cy_3$. When heated with peroxide of mercury, potash, peroxide of iron, and cyanide of mercury are produced, the latter being a most violent poison. To produce Prussian blue on silk with this salt, all that is required is to dip the silk in a slightly acidulated liquor containing a persalt of iron, and when the silk is washed and mordaunted, it is dipped in a weak acidulated solution of yellow prussiate of potash, when it assumes a beautiful blue color due to the formation of Prussian blue. To dye wool, it is necessary to pass it through a boiling bath composed of yellow prussiate, muriate of tin, and a small quantity of sulphuric acid. Prussian blue is gradually formed, and fixes itself on the fibre. To produce blues on calicoes, a solution of yellow prussiate of potash is made, to which is added some tartaric acid and muriate of tin. This mixture, after being properly thickened, is printed on the calico, and then submitted to the action of steam, the Prussian blue so produced being fixed on the cotton fibre, by means of the oxide of tin, resulting from the decomposition of the salt employed.

Nothing is more simple than to gild or silver metals by means of ferrocyanide of potassium, or to cover iron and other metals with copper. To obtain a gilding liquor, it is only necessary to take 1000 parts of water, adding to it 100 parts of yellow prussiate of potash, 10 parts of chloride of gold, and one part of caustic potash. Each of these should be added successively, and the whole of the liquor carried to the boil and filtered. It is then ready for gilding silver or brass objects, when properly attached to the pole of a galvanic battery. The silvering liquor is made by substituting for the chloride of gold, in the above process, ferrocyanide of silver, prepared by adding nitrate of silver to a solution of ferrocyanide of potassium, the white precipitate resulting being washed and added to the liquor intended for silvering. For covering zinc or iron with copper, it is simply necessary to substitute the ferrocyanide of copper for that of silver. Ferrocyanide of potassium, as above stated, is also employed for the manufacture of Prussian blue, which was accidently discovered by Diesback, in 1718, by adding alum, containing iron, to the ammoniacal liquors sold to him by Dippel, which were produced as already stated above, during the distillation of animal refuse. These liquors, being rich in cyanide compounds, yielded with the salt of iron of the alum, Prussian blue. At the present day, Prussian blue is manufactured by different processes, but they are all based on the principle of mixing various salts of iron with red or yellow prussiate, when double cyanides of iron (or Prussian blues) are produced.

(To be continued.)

On a Means of Increasing the Resistance to Rupture of Hydrostatic Cylinders. By St. John V. Day, C.E.

From the Practical Mechanic's Journal, November, 1865.

Hitherto it has been generally assumed that the immediate cause of rupture in hydrostatic cylinders is the pressure of the fluid against their internal walls. Primarily this is the fact, but by careful observations upon the structure of cast iron, of which materials these cylinders are usually, if not always, made, it has been asserted, that although the cause of rupture has its origin with the concentration of external force within the cylinder walls, yet there is reason, as will hereafter be seen, to believe that, carried to the extent it is usual to employ in practice, this, of itself, is not sufficient to produce complete disruption of the mass.

It has long been known that cast iron, when cooled in large masses (such as hydrostatic cylinders, guns, &c.,) has always its portions towards the centre of a density much inferior to that at and approaching to its outward surface; and, although this inferiority may be much reduced by running the metal into the mould, and allowing it to cool under the pressure of a static head of fluid metal, as proposed and experimented upon by Mr. Mallet, in 1840,* still it must ever remain

* Trans. British Association, pp. 304 and 305; Construction of Ordnance, Arts. liv., lv., lvi., and lvii.

an impossibility to bring up the tenacity of the interior portions of a heavy cylinder equivalent to those further from its centre. The laws of cooling themselves, at least, render it impossible, however much the ingenuity of mechanicians may, by the introduction of abnormal circumstances, modify them so that the permanent irregularities of stress may be diminished.

This acknowledged deterioration of the tensile value of cast iron under the conditions above mentioned, has led to a large amount of investigation, both theoretically and experimentally, on the part of the ablest mathematicians and mechanicians, amongst whom, under the first head, may be mentioned, Barlow, Lamè, Rankine, and Hart; under the second, Mallet, Longridge, and others. By the first named of the class, a formula has been proposed, and which has been modified by the others, tending towards an accurate expression for the tenacity of any given cylinder of cast iron; in all probability that of Professor Rankine approximates most closely to the truth.* Various values for the reduction of strength in large castings have been given by those whom we have mentioned under the second head, viz: Mr. Longridge stated, "he felt confident that in a mass of metal, such as that required for a 68-pounder gun, the loss of strength would be at least fifty per cent."† the same author further on remarks: "When that was combined with the loss of strength due to a homogeneous cylinder, it easily explained the bursting of hydraulic presses."‡

This initial drawback to the employment of iron in thick castings, has induced engineers at different periods to suggest, and in many instances adopt means for artificially strengthening them, which, in the case of hydrostatic cylinders and ordnance, has been effected in some instances by shrinking on their exterior, tubes or hoops of malleable iron, or in others by enveloping them in a series of coils of wire. But whatever the objections may be to manufacturing cylinders in this manner one thing is certain, that for hydrostatic presses it has but in a few instances been restored to.

Referring again to Mr. Longridge's paper, we find it there stated, in reference to a hydrostatic press cylinder of ten inches diameter, that, using the "formulæ of Lamè, afterwards deduced by Dr. Hart in his calculations for Mr. Mallet, and by Mr. C. H. Brooks for the author, also arrived at by Professor Rankine by another method, the bursting strength would be $3\frac{1}{3}$ tons per square inch."§

It will not be denied that, up to the present time, it has been impossible to obtain ordinary cast iron cylinders of large size to resist a pressure of three or four tons per square inch—the aggregate of cylinders annually ruptured at a lower pressure fully bear out this conclusion.

The author's attention has recently been drawn to the consideration of certain observations which have been carried on for some time by Messrs. Weems, engineers, of Johnstone, near Glasgow, relative to

* Applied Mechanics, Art. 273.

† Transactions of the Institution of Civil Engineers, vol. xix., Session, 1859-60.

‡ Ibid. § Ibid.

the rupturing action of water as it obtains ingress to the intermolecular spaces of hydrostatic cylinders. It is held by these gentlemen, that the entrance of the water into the substance of the cylinder is in effect equivalent to slicing off a ring of the metal either inside or outside, thereby proportionately reducing its resistance to internal fluid pressure. The action of the water may be referred to an annular series of wedges inserted into every possible crevice in the cylinder's walls, and driven in to rend the cylinder, so that, as each wedge penetrates the substance, the tenacity of the substance is proportionately reduced; similarly the greater the pressure the consequently greater distance will the water obtain vent into the cylinder's substance, when rupture is very easily brought about, the extent of entrance of the liquid also depending, under any given pressure, upon some function of the density of the iron as the exterior surface is reached.

Putting x to represent the distance that the water would enter the cylinder's substance under any given pressure, d the density of the material, and φ the function of increased density as the cylinder's exterior limit is reached, then—

$$x \propto \varphi\ (d).$$

It is a fact that under moderate pressures, water always does find its way completely through so porous a substance as cast iron, and distributes itself over the surface, at first in the form of very fine particles, which by and by aggregate, and may be seen to run like rain drops, in lines extending downwards. Taking it for granted, (as the firm before referred to have done,) that this interstitial entrance of the fluid diminishes the tenacity of the material, it was next sought to obstruct the passage of the water, and from the results that have been and are being obtained, a doubt cannot remain that this difficulty has been speedily and successfully overcome, and that ordinary hydrostatic cylinders may thereby be rendered considerably stronger within their usual working limits. The remedy for this evil consists in placing a very thin lining of a material having great density, and consequent high impermeability, between the liquid and the cylinder—that is, a thin cylinder fitting closely to the bored interior of the ordinary cylinder. The material used for this purpose so far has been copper.

We now have to show whether any truth existed in the previous considerations relative to the supposed injurious influence of the intermolecular entrance of liquid. If the tested cylinders had burst at the same pressure that unlined cylinders had previously done, it is clear that the expense and trouble of lining would have been worse than useless; but this is not the case. Hitherto an ordinary hydrostatic cylinder, unless strengthened externally, having a ram of 24 inches diameter, could not be relied upon at a pressure much above two tons per square inch—certainly not above 2·5 tons. A cylinder of this diameter, bored out and lined as we have previously explained, has been for a long time, and now is working at a contant stress of 3·5 tons, for the manufacture of metallic pipes; and Messrs. Weems believe this press to be perfectly safe at this strain for any reasonable

length of time. Until the introduction of the copper lining they found it impossible to obtain cylinders sufficiently strong to resist the pressure necessary for the manufacture of metallic pipes. The same firm have a 33-inch cylinder also used in the manufacture of metallic pipes, and constructed in the same manner; but we do not know what they consider to be the safe working limit in this instance. That the theory here broached is no myth, is evident from the number of presses that are being constructed on the system in and around Glasgow.

The view set forth is one that for a time may meet with opposition, and it may yet receive another explanation, having reference to a chemical rather than a mechanical cause; probably the exact truth lies in combination of both. It is generally known amongst engineers that if the natural surface is removed from a piece of cast iron, and that in this state it is exposed to atmospheric influences, or is placed so that steam or mist becomes condensed on the exposed surface, in a short time oxidation will have taken place to some distance below the surface, and the tenacity of the iron become diminished in a ratio depending upon the difference of strength of corresponding sections of unoxidated and oxidated portions; in a given specimen the tenacity will vary as a function of the depth to which the oxygen has reached. It is almost certain that after a withdrawal of interior fluid pressure, the elasticity of the cylinder acting on the intermolecularly held particles of water causes them, or a great portion of them, to be extruded, and thus a large portion of the space they occupied is left partly empty, at which time, in all probability, the oxygen attacks the tiny pillars by which each interstice may easily be conceived to be surrounded. As this action goes on, so the tenacity of the cylinder is rapidly reduced, and, as hitherto, breakdown after breakdown has been a continual annoyance and endless expense.

On the Construction of Blast Furnaces and the Manufacture of Pig Iron in the Cleveland District. By Mr. James George Beckton, of Whitby.

From Newton's London Journal of Arts, August, 1865.

Within the last ten years, the blast furnaces which have been erected in the Cleveland district have been gradually increased in size, both in diameter and height; and these alterations have thus far been attended with good results, so much so, that almost all the new furnaces, now in course of erection, are being built with boshes, ranging from 16 feet to 22½ feet in diameter, and from 60 feet to 75 feet in height, from the bottom of the hearth to the filling plates at the top. Previously the furnaces ranged from 13 feet to 15 feet diameter at the boshes, and from 45 feet to 50 feet in height, the extreme increase being about 70 per cent. in both dimensions. The maximum diameter of the boshes appears not yet to have been attained; and the limit to the height will apparently be found in the strength of the coke to support the crushing force of the high column of materials in the large blast furnace. The

make of pig iron has increased at the same time from 200 tons per week in the small furnaces to 300 tons in the large furnaces.

The average quantity of materials used in the production of one ton of pig iron in the large furnaces is as follows:

26	cwt.	of Durham coke,
70	"	Cleveland ironstone,
15	"	of limestone,
10	"	of coal for boilers, hot-blast stoves, and calcining kilns,
121	"	total,

or about 6 tons of materials per ton of iron made. Formerly the quantity of coke used, per ton of iron made, averaged 35 cwt., instead of 26 cwt., and the quantity of coal 20 cwt., instead of 10 cwt. The writer does not attribute the whole of the saving of fuel which has taken place to the increased size of the furnaces alone, as there are several other improvements which have combined to produce an economy of fuel in the manufacture of pig iron in the Cleveland district, of which the following are some of the principal:

First.—The more efficient management which has taken place at the different works.

Second.—The better adaptation of engine power and hot-blast stoves to the requirements of the furnaces.

Third.—The improved system of calcining the ore, which was formerly carried on by clamping in the open air, but is now performed in properly constructed calcining kilns.

Fourth.—The higher degree of temperature of the blast supplied to the furnaces, which was formerly heated in the hot-blast stoves to only 600° or 700° Fahr., but is now very generally being supplied to the furnaces at a temperature of from 800° to 900°.

Fifth.—The plan of taking off the waste gas from the furnaces and burning it at the boilers and hot-blast stoves, in place of using additional coal for this purpose.

The application of the waste gas to the boilers and hot-blast stoves is becoming very general at the different works in the district, and arrangements are now being made at several of the new works in course of erection for applying it to the calcining kilns, for the purpose of calcining the ironstone. The plan in general use for taking off the gas from the blast furnace is the closed furnace top with bell and hopper, sufficiently large to charge from 8 to 10 tons of materials into the furnace at once, and with an arrangement for raising and lowering the bell by hand. The impression seems to be gaining ground that taking off the gas with the closed top, and in connexion with a large chimney double the height of the furnaces, does not interfere with the operations of the large furnace, either as regards economy of fuel or quality and make of iron.

A noticeable feature in the large furnaces is the greater amount of time the materials are allowed to remain in the furnace. The capacity of the Thornaby furnaces, with 20 feet boshes and 60 feet height, is 12,361 cubic feet; the area of the boshes is 314 square feet, and the make of iron 300 tons weekly per furnace. The capacity of the small

furnaces which were formerly erected, with 14 feet boshes and 50 feet height, is 5553 cubic feet; the area of the boshes is 154 square feet, and the make of iron 200 tons weekly per furnace. In the large furnace, therefore, there are more than twice the quantity of materials undergoing the process of heating, and also remaining a longer time in the furnace. Moreover, the area of the boshes in the large furnace being double that in the small furnace, while the quantity of iron produced by the large furnace and, consequently, the quantity of blast supplied is only one and a half times as much as in the small furnace, it follows that the ascending gases pass through the materials at a slower velocity and at a lower temperature in the large furnace. This allows the coke to descend to the zone of fusion without losing so much of its carbon in the formation of carbonic oxide, as previously in the small furnace; and hence arises the greater economy of fuel in the large furnace. To produce 300 tons of pig iron per week, the large furnace requires to be supplied with 8000 cubic feet of blast per minute, at a pressure of 3 lbs. per square inch.

Four furnaces at the Ormesby Iron Works, Middlesborough, belonging to Messrs. Cochrane, erected in 1855, were the largest in the district at that time: the boshes are 16 feet diameter, and the height is 56½ feet. The furnaces are constructed upon land consisting of mud and silt, and piling had therefore to be resorted to, in order to secure a good foundation for the furnaces. A bed of concrete was placed on the top of the piles, and six inverted arches were turned on the top of the concrete and the brick pillars carried up, and strong cast iron bearers fixed across the top, for carrying and binding the brick-work of the barrel and boshes. The outer shell is bound with wrought iron hoops, fixed near enough together to prevent the barrel from cracking. The boshes are at an angle of 75° from the horizontal.

In building four furnaces, in 1858, at the Jarrow Iron Works, Newcastle-on-Tyne, a good strong clay was found for the foundations to rest upon; the brick-work was carried up to the floor line, then twelve cast iron columns were erected, and wrought iron casings fixed on the top of these. The casings extend from the top of the five tuyere houses to the top of the boshes, above which the barrel is bound with wrought iron hoops supported by T irons, the latter being carried up to the top, and a flat ring riveted to them sufficiently strong to carry the floor plates. The boshes are 18 feet diameter, at an angle of 66° from the horizontal, and the furnaces are 60 feet high.

At the Normanby Iron Works, Middlesborough, belonging to the Messrs. Jones, Dunning & Co., three furnaces were erected in 1860, upon a bed of concrete on clay of a weak nature; they are supported on brick pillars, and hooped similarly to the Ormesby furnaces. The boshes are 18 feet diameter, at an angle of 72° from the horizontal, and the furnaces are 58 feet high.

At the Thornaby Iron Works, South Stockton-on-Tees, belonging to Messrs. Whitwell, three furnaces were erected in 1862 upon piles, in consequence of the land being mud and silt; they stand each upon 12 cast iron columns, and are cased with iron, similarly to the Jarrow

furnaces. The boshes are 20 feet diameter, at an angle of 68° from the horizontal, and the furnaces are 60 feet high.

At the Acklam Iron Works, Middlesborough, by Messrs. Stevenson, Wilson, Jacques & Co., three furnaces are being built on piles, in consequence of the land being mud and silt, and are each supported by 12 cast iron pillars. The brick-work around the boshes is cased with plates, and from the boshes up to the top the barrel is bound with hoops and T irons. The boshes are 22½ feet diameter, at an angle of 68° from the horizontal, and the furnaces are 70 feet high. These furnaces the writer believes to be the largest in dimensions that have ever been erected, and their contents will amount to no less than 1250 tons of materials per furnace. They are expected to produce each 350 tons of pig iron per week.

Mr. D. Adamson regretted that Mr. Beckton was unexpectedly prevented from being present at the meeting. With some of the blast furnaces in the Cleveland district he had himself had an opportunity of becoming acquainted; and in reference to the semi-closed plan of furnace top, for taking off a portion of the gas from the furnace throat, as used at the Thornaby furnaces, the construction of top in this case was similar to that in use at Messrs. Schneider's furnaces near Ulverstone; but although at the Ulverstone furnaces it had been found to work so successfully that the same plan was being adopted for more furnaces at the same works, in the particular instance of the Thornaby furnaces it had not been found to answer. The centre tube or brick chimney for taking off the gas was carried upon six arches springing from the inside of the furnace throat, and the charging of the materials into the furnaces was done through the spaces left between the arches; and the reason of the failure of the plan at the Thornaby furnaces was that constant trouble was occasioned by the damage done to these arches in charging, owing to the large size of the material in the charges. The Cleveland ironstone was raised from the mines and supplied to the furnaces in very large pieces, and would not pay for being broken to a smaller size, on account of its friable nature, and the quantity of waste that would be made in breaking it up; and in charging the furnace with these large pieces, they broke down the arches carrying the centre tube, so that this plan had now been abandoned at the Thornaby furnaces, and they were about to have closed tops put on, of the usual construction, for taking off the whole of the gas.

Independently, however, of the trouble arising with the arches in the semi-closed plan of furnace top, it was also found at the Thornaby furnaces that the portion of the gas so taken off was not sufficient in quantity for the purposes of raising steam at the works and heating the blast, even without attempting to use any of the gas for calcining the iron. In the discussion of this subject at the Liverpool meeting, he had urged the desirability of taking off the whole of the gas from a furnace, on account of the large additional heating power then at command; and this view appeared to be confirmed by the experience in the present instance at Thornaby, and by the statement given in the paper just read, that at some of the Cleveland furnaces where the top

was entirely closed, the gas was likely to be employed for calcining the ironstone in addition to heating the steam boilers and the hot-blast stoves.

The President inquired what was the effect of the increased size of the Cleveland blast furnaces upon the quality of the iron made.

Mr. D. Adamson understood that in the larger furnaces, foundry iron was made with rather less trouble than in the smaller ones, and with considerable less fuel, according to the statement in the paper. The charge was thus lighter, and the iron was made at less cost in the larger furnaces, which was attributed in the paper to the greater length of time that the materials remained in the larger furnaces.

The President asked what size of blowing engine was used for the large furnace ot the Acklam Iron Works.

Mr. D. Adamson was not aware what size of engine was used at the Acklam furnaces, but the majority of the Cleveland furnaces were supplied with blast by a number of small blowing engines, and the rest by a single large engine. With regard to the pressure of the blast, he believed 3 lbs. per square inch, or rather less, was usually about the pressure at the engine in the Cleveland district, but he doubted whether the full pressure of the blast was always obtained in the furnaces, as it had been found by applying gauges on the tuyeres at the Thornaby furnaces, that the pressure at that point was considerably below what it was at the engine. At the Norton furnaces of Messrs. Warners, near Stockton-on-Tees, the pressure originally employed of 3½ lbs. per square inch had now been reduced to only ½ lb. per square inch; and he understood the lighter blast was preferred at those furnaces, and that a greater quantity of foundry iron was made than with a heavier pressure of blast.

The President inquired what was the usual number of tuyeres in the Cleveland furnaces.

Mr. D. Adamson replied that from three to six tuyeres were usually employed. At the Norton furnaces three large tuyeres were now used with the light blast, instead of six smaller tuyeres employed previously with the heavier blast; and from the reduction in the pressure of the blast, much less engine power was now required in blowing the furnaces for the same make of iron. At another furnace, however, in the neighborhood, the engines had been kept loaded to 2¾ lbs. per square inch pressure, while the pressure of the blast was reduced by throttling its passage through the main by means of a stop valve; and in that instance, consequently, the full benefit of saving in engine power by working with a lighter blast had not been realized.

Mr. G. Thomson observed that the size of the blast furnace was a very important subject to iron makers, and one upon which experience differed a good deal; and it was therefore highly desirable to get all the information possible, in order to make a fair comparison between different sizes of furnace. One point to be inquired into was the relative quantity of iron produced and of blast supplied in the large and small furnaces. In the large furnaces, 60 feet high, and 20 feet diameter boshes, making 300 tons of iron per week, the quantity of

blast had been stated in the paper to be 8000 cubic feet per minute; and he inquired what was the quantity of blast supplied to the smaller furnaces, 50 feet high, and 14 feet diameter of boshes, making 200 tons of iron per week.

Mr. Neil Robson did not know the quantity of blast supplied in the smaller Cleveland furnaces, but in the blast furnaces of the Glasgow district the quantity of blast supplied to a furnace about 50 feet high and 16 feet diameter of boshes, was usually supposed to be about 6000 cubic feet per minute.

Mr. C. Cochrane thought the 8000 cubic feet of blast per minute, which had been stated to be the supply to the large Cleveland furnaces, must be the theoretical quantity measured by the total displacement at the blast engine, without any allowance being made for escape between the piston and the cylinder and for leakages in the blast main; for the quantity of coke consumed in the furnace—26 cwt. per ton of iron made—would not require, he thought, more than 6000 to 6300 cubic feet of blast per minute, and he could not understand, therefore, so much as 8000 cubic feet per minute being supplied to the furnace.

Mr. G. Thomson remarked that 6000 cubic feet of blast per minute would be a maximum quantity in Staffordshire, and there were many furnaces of a smaller size in that district in which a much smaller quantity of blast was supplied.

Another point upon which further information was required in connexion with the Cleveland blast furnaces was the temperature of the blast in the large and small furnaces, and whether the large furnaces had been worked with the lower temperature of blast used in the smaller ones. It appeared from the paper that the blast for the larger furnaces was heated to 800° Fahr., while in the smaller furnaces the temperature had not been carried beyond 600°; and in order that a fair comparison might be arrived at between the different sizes of furnace, he should be glad to know the result of working the larger furnaces at the lower temperature of 600°, the same as the small furnaces, since the conditions of working should be made as nearly as possible the same in the different furnaces. The actual temperature of the blast, he believed, was generally much higher than was indicated by the ordinary rough test of holding a strip of lead in the blast to be melted by the heat; since, in order to melt the lead at all under such circumstances, the temperature of the blast must be considerably above the melting point of the metal, and the real temperature was, therefore, not ascertained with any approach to accuracy by the plan of melting metals in the blast. He inquired how the heat of the blast was ascertained when it was much above the melting point of lead, and whether any pyrometer was employed for showing the temperature accurately.

Mr. C. Cochrane replied, that for temperatures above that indicated by the melting of lead in the blast, a strip of zinc was used as the test instead of lead, and by that means a temperature as high as about 850° was indicated, the melting point of zinc being 770° Fahr.; for the actual temperature of the blast, when hot enough to melt either lead

or zinc, was found to be as much as 80° or 90° above the melting point of the metal. This was ascertained to be the case, as a general rule, whatever the melting point of the metal employed, as was shown by the aid of the improved pyrometer constructed on the principle of measuring the temperature of a copper ball heated in the blast by immersing it in a vessel of water, which afforded the means of measuring with the greatest accuracy the highest temperatures that were likely to be met with in practice.

Mr. E. A. Cowper explained that the pyrometer referred to was an improved arrangement of that invented by Mr. John Wilson, and described at a former meeting of the institution, and was a very simple and accurate contrivance for measuring high temperature. It consisted of a copper vessel holding exactly a pint of water, and a small cylindrical piece of copper made of such a size that its total capacity for heat should be 1-50th that of the pint of water; this copper piece was held for a sufficient time in the current of heated blast until it had acquired the full temperature of the blast, and it was then dropped into the vessel of water, when each 50° that the temperature of the copper had been raised produced a rise of 1° in the temperature of the water; and thus the real temperature was at once read off from a thermometer inserted into the water, having a properly divided scale showing 50° for each 1° of the ordinary scale. It was by this means that it had been ascertained that, when the heat of the blast was tested by a stick of metal being just melted on exposure to the current, the actual heat of the blast was about 70° to 90° Fahr. above the melting point of the metal. Thus, if lead melting at 620° were just melted by the blast, the heat of the blast might be taken to be about 690°; zinc melted at 770°, and would show about 840°; the antimony did not melt at less than 830°, and its melting would, therefore, indicate about 900°. Of course, if the stick of metal were melted quickly in the blast, it showed that the temperature was much higher than the melting point of the metal; and ordinarily the sticks of antimony of about 5-16ths inch diameter became fused in three or four seconds by exposure to the heated blast from the regenerated hot-blast stoves.

Mr. Neil Robson observed there could be no doubt as to the importance of the question of the height of blast furnaces; and it appeared from the paper a height of 70 feet had now been reached in the Cleveland district, while in the neighborhood of Glasgow, the highest furnace was only 55 feet, and generally the furnaces were not more than 42 feet high. At the Ardeer Iron Works, in Ayrshire, where there were four furnaces, each 52 feet high and 16 feet diameter at the boshes, the regular make of iron was 1000 tons per week, or an average of 250 tons per week from each furnace. Occasionally, one or two of the furnaces would make 270 tons per week, while the others might make less than 250 tons at the same time; but 1000 tons per week was the regular average make throughout the year, taking all four together. The highest make in the Cleveland district was stated at about 300 tons per week, with 60 feet height and 20 feet diameter of boshes; but, in comparison with the Scotch furnaces, the make of the larger Cleve-

land furnaces ought to be as much as 400 tons per week for the size of furnace used. The temperature of blast employed was in both cases from 800° to 900°, and the pressure about 3 lbs. per square inch. Hence, he thought, the cause of the smaller produce of the large Cleveland furnaces was to be sought in the materials that had to be worked, the nature of the ironstone to be smelted, and the quality of the fuel to be used. In the Ardeer furnaces the ore employed was, in a great measure, the blackband ironstone, and the fuel was raw coal; and he presumed these must be easier smelted than the materials in the Cleveland district, since the Scotch furnaces, though so much smaller, produced nearly as much iron in the same time.

Proc. Mech. Eng. Soc.

To Preserve the Plasticity of Clay.

The suggestion has been made to mix clay into glycerine in place of water for the purpose of keeping it in a plastic state for modeling or as a lute in chemical apparatus. To do this effectually, the clay must be first thoroughly dried and finely powdered, then mixed with glycerine of specific gravity, 1·231; clay thus prepared preserves its plasticity indefinitely. But if, on the other hand, the glycerine is added to the clay while still moist, or if the glycerine itself contain water, an evaporation is established and the clay becomes dry and hard as usual. To render the clay proper for modeling is said to require one-third of its weight of glycerine,—which is a large first outlay, but may be found economical, since it retains its properties indefinitely and requires no farther preparation.

Preparation of Oxygen By R. W. Artlett

From the London British Journal of Photography, September, 1865.

Having experimented on the valuable process for obtaining oxygen by the action of peroxide of cobalt on solution of hypochlorite of lime, with the view, among other things, of ascertaining what other substances might be possessed of the curious powers of the peroxide of cobalt, I have found that moist peroxide of iron or oxide of copper will answer the purpose. These substances, in the repeated trials I have made, have caused the evolution of a volume of oxygen equal to that obtained by means of the oxide of cobalt, and, like it, they lose none of their efficiency by use. The only difference I have observed is that, perhaps, the oxide of iron requires rather the highest heat to cause an equally rapid disengagement of gas. The oxide of copper answers perfectly, and if the oxide be not at hand, a few drops of nitrate of copper may be added to the hypochlorite of lime solution, and the gas will be given off abundantly immediately on the application of heat.

I have also tried peroxide of manganese, but have not yet sufficiently investigated its action. I may, however, state that it does not ac-

complish the end in view so well as the other substances. The quantity of oxygen liberated is smaller, and permanganic acid is formed.

Dalton's Thermometer.

From the London Chemical News, No. 279.

At a recent meeting of the Manchester Literary and Philosophical Society, Mr. Baxendell stated that the Society had in its possession a thermometer, constructed by the late Dr. Dalton, and which, it is believed, was used by him in many of his meteorological observations. The scale had the initials "J. D." and the year "1823" engraved upon it; and the freezing and boiling points of water are indicated on the stem by fine file marks. As it is known that the zero points of thermometers sometimes change to the extent of one or even two degrees in the course of several years, it occurred to Mr. Baxendell that it would be interesting to ascertain whether any change had taken place in this thermometer, and he had, therefore, lately tested very carefully the position of the freezing point, but found that no sensible alteration had taken place; and he believed, therefore, that great confidence might be placed in the observations which Dalton had made with this instrument.

Artificial Stone.

From the London Mechanics' Magazine, September, 1865.

To obtain a factitious stone which may take the place of the ordinary Turkey, Water of Ayre, and Arkansas stones used for sharpening cutting tools, and for kindred purposes, is the object of an invention recently patented by Mr. E. Parnacott, of Leeds. To this end he prepares a compound which will admit of being moulded to any required form, and which, when moulded may be hardened and brought to the consistency of stone. In carrying out the improved manufacture, the chips and dust obtained in preparing lithographic stones are reduced to fine granules, emery powder, borax, and saltpetre are added, and the whole thoroughly mixed in a mill. The mixture thus obtained is moulded to any required shape—for example, cutting and polishing tools; the same is first submitted to hydraulic pressure, and then to furnace heat, whereby the hardness and consistency of stone is imparted to the moulded articles. The following proportions will produce a good result, viz: pounded lithographic stone twelve ounces, borax two ounces, saltpetre half an ounce, and very fine emery two ounces. Place these substances together in an ordinary incorporating mill with edge runners, (such as is used for preparing mastic and sand,) the pan of the mill being heated by steam or gas, and subject the substances to the action of the mill until they are well mixed and incorporated. Then remove the compound thus formed and place it in strong iron moulds for the purpose of being submitted to pressure. These moulds are made of various shapes to suit the purposes for which the artificial stone is to be used.

The pressure necessary to effect a proper consolidation of the compound may be conveniently given by means of a strong hydraulic press. The amount of pressure which has proved satisfactory is about twenty tons per square inch of surface of the moulded article. When the requisite mechanical consolidation of the moulded article has been thus obtained, the moulded article is subjected to a white heat in any suitable construction of furnace, or to such a heat as will serve to fuse the borax and saltpetre, and effect the binding together of the granules of stone and emery. The time required for attaining this object will in general be from half an hour to one hour. To prevent the warping and running of the moulded compound under heat, it is clamped in moulds made of plumbago, fire-clay, or other like heat-resisting material, before being placed in the furnace. When it is required to produce cutting or polishing wheels, hones, or other like articles with a less cutting power than those made from the before-named mixture, ordinary chalk is substituted for a portion of the lithographic stone granules. The proportions of the chalk and the granules should be half of each to produce a good result, the proportions of the other materials being retained.

On the Effect of Blowing Blast Furnaces with Blast of very High Temperature. By Mr. E. A. Cowper.

From the London Artizan, November, 1865.

It is not proposed to detain the meeting with a history of the numerous attempts which have been made to raise the blast furnaces to a very high temperature, nor will the author occupy much time in the description of the means by which the desired result has been obtained, as a full account of the apparatus was given at the meeting of this Association held at Oxford, (though the paper on the subject was not printed in the Transactions.) In 1861, experimental stoves only on the new plan had been erected, and worked for heating the blast for one tuyere, out of the five used for one blast furnace. Such satisfac tory results were however obtained, that it was clear that the difficulty of procuring blast of very high temperature had been overcome, and Messrs. Cochrane & Co., of Woodside Iron Works, Dudley, and Ormesley Iron Works, near Middlesbro'-on-Tees, forthwith erected large stoves on the new plan for a complete blast furnace; and it is now proposed, with your permission, to lay before the section the results obtained during upwards of six years practical working with these stoves. The effect of heating air on the new plan was that a temperature of blast of 1150° Fahr. was obtained, instead of only 600 or 700°, as with cast iron pipes in the common stoves. There was no loss of blast from leakage, owing to the cracked or damaged cast iron pipes; the iron produced was of rather better quality; 20 per cent. more iron was made from the same furnace; and fully 5 cwt. of coke was saved in the blast furnace per ton of iron made. The details of the construction of the new stoves will be easily understood.

First, there are two stoves, which are heated alternately, and used alternately in heating the cold air; these are filled with brickwork, "set open," (or small spaces between the bricks,) and from "regenerators" on the principle of Mr. Siemens' regenerator furnaces as now so largely and successfully used in glass houses, gas works, iron works, &c., both for obtaining great heat and economizing fuel. The outsides of the stoves are of thin wrought iron plate, lined with fire brick, the iron skin being necessary to retain the blast under pressure, whilst the fire brick resists the heat. Second, there are provided for the purpose of heating the stoves, valves for the admission of gas and of air into a central flue, where combustion takes place when a stove is being heated, the products of combustion passing up the flue and down through the mass of fire bricks forming the regenerator, and escaping at the bottom to the chimney, after the whole of the heat has been abstracted by the fire bricks, the temperature of the chimney being from 212° to 250°, or thereabouts, during the time a stove is being heated, viz: for a period of four hours. Then when a stove is hot, the gas and air are turned off, the chimney valve shut, and the cold blast is turned on at the bottom of the regenerator, and passes up through the bottom courses of brickwork in the regenerator, this very quickly becoming heated, and passing in this heated state up through the remaining courses of hot brickwork, and down the central flue through the hot blast valve to the blast furnace, the process of absorption of heat by the air being so perfect that as long as a few of the top courses of brickwork remain hot, the blast is well heated, the variation in the temperature of the blast being 100° Fahr., with four hours changes. Thirdly, the gas for heating the stoves was supplied from gas producers, similar to those commonly used by Mr. Siemens for his regenerator furnaces and which have been already described before the Association. They consist of a simple brick enclosure, or fire-place, with bars near the bottom for the admission of a very small quantity of air. The gas is formed by the slow combustion of a very thick fire, supplied with poor coal or slack, down a slope or hopper, the gas passing off from above the fuel through pipes to the hot blast stoves. Gas may, however, be taken from the top of the blast furnace for heating the stoves, provided proper arrangements are made to separate it from the dust which comes over from the blast furnace with it; and judging from recent practical experiments, it is certain that there are several ways in which this may be done with perfect success. The late Mr. James Beaumont Neilson, who did so very much for the iron manufacture by his original invention of the hot blast in 1829, was sufficiently long-sighted to predict the advantages that would flow from the use of blast of very high temperature, though, as it happened, he was limited to what could be obtained from passing the air through iron pipes exposed to a fire, as in common stoves. Mr. Neilson said, "In the new generator ovens that had just been described, the great capacity of fire brick for heat had been well taken advantage of, and a very important step in advance had been made by giving the means of raising the temperature of blast much above the extreme limit prac-

ticable with the old ovens; and he considered this would be productive of the greatest benefit in the working of the blast furnace—he had no doubt the 'make' of iron would be considerably increased by the higher temperature of blast given by the regenerative ovens. These anticipations have been fully borne out in practice during upwards of four years regular working of the stoves. The high temperature of the blast produces such an improved effect in the furnace, that the 'burden' is increased so as to save fully 5 cwt. of coke per ton of iron made; and as there is less fuel supplied, so there are less impurities taken in, and the quality of the iron is improved, the tuyere breasts do not work hot or burn, or give more trouble than usual, as the burden is increased as just stated. The same furnace is of course enabled to do more work, the 'make' being increased fully one-fifth, so that a given plant produces 20 per cent. more iron per annum, besides saving nearly three shilling per ton for coke. There is less friction or loss of pressure of blast in these stoves than in common ones; and there is no loss of leakage through cracked or burnt cast iron pipes or joints. More stoves are now being erected on the same plan."

Mr. Siemens said that the application of regenerators which Mr. Cowper had brought before the meeting was one of the most interesting which could have been made. He had provided the means of heating blast really up to the temperature at which bricks would melt. Mr. Siemens defined the chemical process effected by Mr. Cowper's arrangement, and affirmed that there was no deterioration of the quality of the iron produced by that process. After other remarks, Mr. Cowper was thanked for his paper.

Proc. Brit. Association.

Gases Dissolved in Cast Iron.

M. Cailletet has communicated to the Academy of Sciences at Paris, a series of experiments upon the nature of the gases dissolved in cast iron. The result in two cases of iron of very different composition, was as follows:

	English grey-cast. Made with coke.	Feebly grey. Made with charcoal.
Hydrogen,	33·70	38·60
Oxide of carbon,	57·90	49·20
Nitrogen,	8·40	12·20
	100·00	100·00

M. Cailletet could not satisfy himself whether the nitrogen was or was not derived from a little atmospheric air hanging about the apparatus, nor could he succeed in making any satisfactory determinations on the gases dissolved in melted steel.

Extract from the Monthly Report of the Engineer of the Manchester Association for the prevention of Boiler Explosions.—July 4, 1865.

From the London Artizan, August, 1865.

Explosion No. 27, which was of a very disastrous character, two persons being killed and seven others injured, occurred at a brewery on June 1, to a boiler not under the inspection of this Association. I made a personal investigation a day or two after the explosion had occurred, and found that it arose simply from collapse of the furnace flue, a subject to which this Association has called such constant attention in its reports.

The boiler was of ordinary Cornish construction, having a single furnace flue, internally fired. It was 32 feet long, 7 feet in diameter in the shell, and 4 feet in the internal furnace and flue tube, which was $\frac{7}{16}$ of an inch thick, while the safety valves were loaded to a pressure of 50 lbs. and upwards.

The flue tube collapsed from one end to the other, rending at the angle iron at the back of the shell, as well as at some of the other ring seams of rivets. The boiler was moved forward away from the chimney for several feet, and the greater part of its setting torn down, while the rush of water from the furnace end carried away a considerable portion of the engine house wall, and scalded the workmen near the boiler.

The explosion was atrributed, as usual, by general report, to shortness of water, but examination of the plates showed no evidence of overheating. There could be no doubt that the explosion resulted entirely from the weakness of the flue, which was insufficient for any pressure above 30 lbs., but could have been made perfectly safe at 60 lbs., or even at a much higher pressure, by the introduction of flanged seams, or encircling hoops of T-iron, or bridge rail section, applied at the ring seams of rivets. There are also other means for strengthening furnace flues, such as water pockets, or water tubes, &c.; but since these strengthening pockets or water tubes cannot extend into the furnace, it is well to supplement them at that part with flanged seams or T-iron hoops. After boilers are completed and set to work, the furnace tubes can readily be strengthened with angle iron hoops made in segments so as to be passed into the boiler through the man-hole, and fixed to the tube when in place. Full particulars of this method of strengthening furnace tubes were given in the report for June, 1862, and a considerable number of boilers under the inspection of this Association have been strengthened in this way.

It seems difficult to understand how any maker could have constructed a boiler within the last few years without adopting any one of the simple means to provide against collapse which have just been enumerated above and are now so generally known. The explosion clearly shows the importance of an independent system of periodical inspection for boilers of even first-class firms, where they suppose themselves to be perfectly free from danger; and had the boiler in

question been under the charge of this Association, not a day would have been lost in apprising its owners of the dangerous position they were in.

The jury found that the deceased met with their deaths from the accidental bursting of the boiler, adding that they considered that the furnace flue had not been of sufficient strength for the pressure.

Accidents from Steam Machinery.

From the London Journal of the Society of Arts, October, 1865.

In consequence of the removal of certain restrictions respecting the employment of steam power in manufacture, the *Moniteur* has collected and published an account of the accidents which happened through the use of steam during the past year. It appears that the accidents were only sixteen in number, but that the number of persons who were killed, or died afterwards of the injuries inflicted, amounted to forty, and that fifteen other persons were wounded more or less seriously. Of the sixteen accidents, four occurred in sugar works, three in paper manufactories, two each in distillery and drug works, and one each in other industries. The causes of accident are classified as follows: Eight occurred by the explosion of cylindrical boilers, three by that of tubular boilers with interior furnaces, one by the explosion of a locomotive, and four by that of steam heating apparatus. The immediate causes are supposed in eight cases to have been the bad quality of the metal employed, or the vicious arrangement of the furnaces; in seven others, carelessness or want of superintendence on the part of engineers or stokers, and in the remaining case from the imprudence of other persons. The *Moniteur* gives the details in each case, in order that manufacturers may take warning for the future. This return, of course, does not include railway or other accidents which occurred in connexion with, but were not immediately caused by steam machinery.

Effluvia from Sewers.

From the London Mechanics' Magazine, September, 1865.

The effluvia which escape from sewers, in the very attempt to ventilate them, are of a very pernicious character, and have often been productive of mischievous effects. M. Robinet, a French chemist, has devised a very effective means of freeing the sewers from them. His plan has already been carried out on a small scale. He proposes that the furnaces of factories shall derive their supply of air from the sewers; the latter will thus be emptied of their mephitic gases, which will be destroyed by combustion, fresh air from the atmosphere supplying their place. He calculates that if the combustion of only 70,000 tons of coal can be thus economized annually in Paris, or only a tenth part of what is burned there, the sewers will be supplied with about 140,000,000 cubic feet of fresh air—that is, more than seven times their contents—daily.

*On the Fracture of Polished Glass Surfaces.** By F. H. WENHAM.

From the London Mechanics' Magazine, October, 1865.

The short communication which I submit to your notice scarcely merits consideration as a discovery; but as the microscope has in this case immediately detected the cause of a well known phenomenon, I bring it forward as an example of the use of the instrument in practical investigations. It is a fact known to the philosophical instrument makers, that if a metal wire be drawn through a glass tube, a few hours afterwards the tube will burst into fragments. The annealed glass tubes used for the water gauges of steam boilers are sometimes destroyed in this way, after the act of forcing a piece of cotton waste through them with a wire for the purpose of cleaning the bore. This will not happen if a piece of soft wood is employed. The late Andrew Ross informed me that on one occasion, late in the evening, he lightly pushed a piece of cotton wool through a number of barometer tubes with a piece of cane, for the purpose of clearing out any particles of dust. The next morning he found most of the tubes broken up into small fragments, the hard siliceous coating of the cane proving as destructive as he had previously known a wire to be.

After having drawn the point of a steel burnisher over the surface of a slip of polished glass, the following appearances will be observed under the microscope, using the polarizing apparatus and selenite plate with a two-thirds object glass. A colored stripe is visible in the passage of the burnisher, showing that the surface of the glass has been placed in a state of tension in the direction of the line. The glass, too, seems not altogether devoid of plasticity, for the waves of color show that it has been carried forward in ripples, resembling the mark left on a leather bound book after the passage of a blunt point. It may be inferred from this that the mere burnishing of the surface of the glass with a substance inferior in hardness will, without any scratching, cause an irregular strain in the bore of tubes sufficient to split them, and the concussion attendant upon the fracture often reduces the tube to small fragments. If the burnished lines upon the glass slip be examined a few days afterwards, the colors will have become much less visible, showing that the strained portion of the glass partly recovers its equilibrium.

On attempting to polish out a minute scratch on the surface of a piece of glass, it sometimes appears to widen during the process, and at length resolves itself into two irregular parallel rows. Also, a clean cut made with a diamond on a piece of plate glass, if left for a time, the surface in the vicinity of the cut will break up, forming a coarse irregular line. If the diamond be raised and struck lightly on the surface of the glass, the form of the edges of the short stroke thus made may be plainly seen, using the binocular polariscope. A conical ridge of glass appears to be left with its apex under the line of the cut, and the glass is frequently wedged up on both sides of the ridge, explaining the cause of the double line of fracture which sometimes makes its appearance in polishing out a scratch. This effect may also

* Read before the Microscopical Society.

be exemplified by observing the marks left on a polished glass surface from the light blows of a steel centre punch. The point of the punch drives in an atom of the glass, and the fracture extends some distance into the interior, expanding downwards in the form of a truncated cone. The polariscope shows that the conical centre is in a state of compression, and that the surrounding exterior portion of the glass is also under strain. The smooth, round edge of a glazier's diamond, when drawn over a polished glass surface, burnishes down and compresses the glass beneath the cut, and in the case of thin sheets the wedge-like force of the compressed line splits the glass nearly through, but when the glass is thick and rigid, as plate glass, unless the sheet is bent back and broken through immediately after the cut, greater difficulty will be experienced if allowed to remain for a time, for the compressed line of glass will speedily tear up the portion on both sides, leaving a wide ragged grove in place of the original clean and scarcely visible line.

For the Journal of the Franklin Institute.

The Giffard Injector. By CHARLES E. EMERY, Asst. Eng. U.S.N.

The writer, by permission, recently tried some brief experiments with a view of ascertaining the cost of forcing water with a Giffard injector, an account of which may not be uninteresting, inasmuch as there is a wide difference of opinion in regard to the economy of using this device for feeding boilers. The injector employed was one of moderate size attached to the auxiliary boiler of the U. S. Steam Expansion Experiments. The water was supplied from a tank, with a head of from three to four feet, and was delivered by the injector into a pipe with two branches, one connected to the boiler, and the other to a water chamber, having attached to it a steam gauge and safety valve. Each branch of the pipe was provided with a stop valve, so that the water could at pleasure be forced into the boiler or out of the safety valve on the water chamber at the desired pressure shown by the gauge. Before starting an experiment, the boiler was supplied with sufficient water to last an hour without feeding, the boiler and water chamber gauges being compared by opening valves on both branches of lower pipe when the injector was in operation. The water connexion with boiler was then carefully closed. During the experiments the water was measured before being supplied to the injector; the safety valve on the water chamber was loaded to the desired pressure, and the injected water passed through it, and was again carefully measured, the increase in quantity showing the amount of steam drawn from the boiler. The "overflow" water was collected in a separate vessel and returned to the first tank. The following table shows the best results of the experiments under the conditions expressed. The pressures and temperatures are the means of records taken every fifteen minutes.

No.	Duration of Experiment.	Average Pressures.		Average Temperatures.			a		b	$b-a$	$b \div (b-a)$
		Boiler.	Water chamber	Water in tank.	Discharged water.	Water from tank.		Discharged water.		Difference equals amount of water evaporated.	Ratio by weight of water evaporated to water discharged.
	Minutes.	Pounds.	Pounds.	Degrees F.	Degrees F.	Cubic ft.	Pounds.	Cubic ft.	Pounds.	Pounds.	
1	60	70	62·0	43·0	127	18·37	1146	20·01	1232	86	14·32
2	60	69	62·2	42·4	124	17·87	1115	19·25	1186	71	16·70
3	60	66	75·8	43·0	125	15·94	994	17·50	1078	84	12·83
4	30	61	40·0	44·0	112	9·13	570	9·88	611	41	14·90

In three of the above experiments the average pressure of steam exceeded that of the water. In No. 3 the water pressure was in excess, and it was found that it could be carried much higher without stopping the operation of the injector. In one instance, with seventy pounds of steam, by weighting the safety valve on water chamber, the water pressure was increased to one hundred and ten pounds, which caused a larger "overflow," and less water was delivered under pressure.

The above would seem to indicate that the injector forces, against pressure, sufficient water to condense the steam used. Two of the experiments fall short of this by calculation, due probably to the heating of the small quantity of "overflow" water. The better result of No. 2 over No. 1 was doubtless occasioned by the adjustment of the valves, a smaller quantity of water being delivered, but at a less comparative cost. Nos. 3 and 4 indicate that small changes in the relative pressures of steam and water have some little influence on the ratio.

Assuming as the best result that one pound of steam will force sixteen pounds of water against a pressure of sixty pounds, or one hundred and thirty-eight feet high, thus performing 2208 foot-pounds of work, and, bearing in mind that few steam engines use more than one pound of steam per horse power per minute, we find that the injector requires nearly fifteen times the quantity of steam used by a steam engine to do the same work, or a steam pump should force nearly fifteen times as much water as an injector, when using the *same* quantity of steam.

For feeding *cold* water to a boiler the injector is more economical, as it returns through the feed water all the heat it takes out in the steam, and the pump, though it requires less steam, wastes all the heat of what it does receive. When, however, the pump is used in connexion with a condensing engine or heater, so that the temperature of the feed water is raised to upwards of one hundred degrees, there can be no question of its superior economy, as it will convey to the boiler, by means of the feed water, a greater number of units of heat from the exhaust steam of the main engine than will be required for the steam to drive the pump itself.

The value of an injector, as simply an auxiliary feed to a steam boiler when the engines are stopped, cannot be doubted, but for constant use as a boiler feed, under ordinary circumstances, the force pump would seem to be preferable, and that can be most economically operated by the main engine, for the cost of the power in a small engine is proportionately much greater than in a large one—a point apparently ignored in these days of independent feed, air, and circulating pumps.

Alloying of Iron and Steel with Tungsten.

From the London Mechanics' Magazine, September, 1865.

There has been considerable controversy from time to time as to the effect which is produced upon iron and steel by alloying them with

small portions of tungsten. "Tungsten steel," especially excited much attention some seven or eight years ago. It was first produced in some Austrian steel works, and at first, says Dr. Hoffman, "appeared so successful as to threaten a complete revolution in the working of cast steel." Never before, according to the partisans of the new alloy, had steel been produced of such tenacity and hardness. They declared that ordinary cast steel of best quality, hardened by the usual means, could be turned and bored by tools of tungsten steel. They cited analyses to show that the swords of Damascus, so celebrated for their hardness and elasticity, contained traces of tungsten, and to these they attributed the fine qualities of those weapons. They alleged that the new steel cost less than the best English cast steel, and lasted four times as long. Every where patents were taken out for alloys of steel and tungsten, in this country Mr. Mushet alone obtaining nine in one year. Tungsten steel seems, nevertheless, to have been a delusion. Many eminent metallurgists, among them Dr. Percy, Mr. E. F. Sanderson, of Sheffield, and Professor Tunner, of Leoben, declined to believe in it from the first, and nobody believes in it now. There seems ground, however, for the idea that the addition of tungsten to cast iron improves its quality. A recent number of the *Annales de Chemie* contains an account of numerous experiments which have lately been made by M. le Gruen at the Marine Foundry at Nevers, which appear to prove pretty conclusively that cast iron has its tenacity increased by about one sixth by the addition to it of about two per cent. of tungsten. The tungsten was added, of course, as wolfram, metallic tungsten not having hitherto been available.

On Chain-testing Machines. By Sir W. G. Armstrong, C. B.

From the London Journal of the Society of Arts, No. 730.

The engineering firm of which I am a member having been entrusted with the construction of the apparatus for testing chain cables and anchors, lately established at Birkenhead by the Mersey Harbor Trustees, had occasion to enter into a very careful consideration of the conditions requisite for effecting the operation in the best possible manner. As public attention has been forcibly directed of late to the importance of more accurate methods of testing chains and anchors, a few observations on the subject of the Birkenhead machine will not at the present moment be mistimed.

The most important consideration in the construction of a chain-testing machine is to obtain an accurate indication of the strain upon the chain. The hydraulic press has been for many years the appliance usually employed for exerting the strain, and nothing can be better fitted for the purpose; but the methods of determining the amount of the strain have been extremely imperfect. Most commonly the strain has been estimated by the indications of a mitred valve pressed down by a lever and weight. The impossibility, however, of

restricting the tightening surface of the valve to a definite annular line, so as to exclude any variation of area, rendered this mode of indication highly delusive; so much so, indeed, that the attendants generally paid more regard to the indication afforded by the crackling of the scale on the surface of the iron than to the amount of load upon the valve. By substituting a loaded plunger for a loaded valve, the uncertainty arising from variability of surface is obviated, but a plunger requires a packing to make it water-tight, and the effect of the friction of this packing has to be considered in relation to the friction of the press. A plunger without friction would give untrue indications of the strain, unless the press were also without friction; but friction cannot be avoided in the press, and therefore friction becomes a necessary element of accuracy in an indicating plunger. To make this more apparent it is only necessary to consider that in the press the friction of the packing lessens the tension exerted on the chain, while in the case of the indicator the friction of the packing lessens the weight necessary to indicate the pressure. If, therefore, these two frictions be in harmony, the load on the indicator will be diminished in the same proportion as the tension on the chain, and thus a direct indication of the strain upon the chain will be obtained.

The proper and usual packing for the hydraulic press is a cupped leather, but as the lip of the leather is pressed against the surface of the ram by the action of the water, the amount of its friction varies directly as the pressure. It is therefore necessary that the indicating plunger should also be packed with a cupped leather, in order that its friction may likewise vary directly as the pressure. But as the ratio of circumference to area is very much greater in the small ram of the indicator than in the large ram of the press, it is obvious that with similar leathers the relative friction would be widely different in the two cases. The friction may, however, be brought to a proper adjustment by reducing the breadth of the lip in the leather of the indicator until its friction is in unison with that of the press leather. This adjustment should be made when the press ram and the indicator plunger are both perfectly clean and free from any lubricating substance, and in no subsequent use of the machine should either oil or grease be applied to these parts. The effect of employing a lubricator is to diminish the friction in the first instance, but afterwards to increase it, because the unctuous character of the lubricant is soon exchanged for a stickiness which produces an opposite effect. In fact, when grease or oil is used the frictions become so irregular as to render impossible an accurate correspondence between the press and the indicator.

There is another desideratum in the testing of chains which requires a further elaboration of the indicating apparatus. When a chain breaks in the test it is desirable to show, not only that it failed to bear the full test strain, but also what was the amount of the strain exerted at the moment of fracture. In the case of the Birkenhead machine, various indicators, upon the principle of those commonly used for steam pressure, were tried for the purpose of effecting this latter object, but none of them gave satisfactory results. An apparatus was therefore

designed for the object, which has since come into very general use, under the name of the "pendulum indicator." In this apparatus the pressure upon the indicating plunger is exhibited by the travel of a pendulum through a graduated arc. The movement is communicated from the plunger to the pendulum through the medium of a compound lever. When a chain breaks the pendulum falls back until stopped by a ratchet, but leaves a marker at the exact point on the scale attained by the pendulum at the point of rupture.

I have hitherto spoken of friction only in reference to the packing of the apparatus. This friction, as I have already stated, varies with the pressure, but there is also the constant friction due to the weight of the moving parts to consider. If the machine be used exclusively for high strains in relation to its weight, this constant friction will be unimportant, but if a heavy machine be used for testing light chains, a considerable element of error will be introduced, unless a proportionate friction of the same constant character be added to the indicator. Still, however, it is better that very heavy machines should not be used for testing very light chains, unless they be constructed with more than one press, to act separately for light chains and conjointly for heavy chains. With this view the Birkenhead machine has three presses, the centre one being used alone for light strains, and the three acting in concert when great strains are to be exerted.

Although an hydraulic indicator, properly constructed and correctly adjusted in regard to its friction, may be safely relied upon as indicating with sufficient precision the strain exercised by the machine, yet, for the purpose of ascertaining in the first instance when correct adjustment has been attained, and also for detecting any discrepancy which may subsequently arise from dirt upon the ram or plunger, or from any other cause producing irregular friction, it is necessary that every machine should be provided with a lever indicator, to which the strain may be immediately applied, and the strain ascertained by the lifting of a weight. Such an apparatus requires to be accurately fitted with knife-edge bearings, in order to afford delicate indications, but as these are liable to deterioration by too frequent use, it is better to reserve the lever apparatus as a standard of reference for adjusting the hydraulic indicator, which is not liable to deterioration by use. It is not necessary that the lever indicator should range as high as the hydraulic indicator; for if the two indicators register alike through a sufficient series of the lower strains, no discrepancy would be manifested if the comparison were carried to the highest powers of the machine.

I may here mention that nothing so soon deteriorates the lever apparatus as inadequate length of the knife-edges in relation to the strain upon them. The conclusion arrived at in the Elswick Works is, that not less than one inch length of edge should be allowed to every five tons of strain upon the bearing.

In the arrangement of a public chain-testing establishment, it is desirable that the apparatus for the various operations should be placed in such succession as will allow the chains to move from pro-

cess to process without any retrogression. The Birkenhead Chain-testing Establishment commences with a store room for the reception of unproved chains. From this store each chain is dragged by a steam power capstan through an opening in the partition wall on to the testing bench of the machine. It is there made fast, at the one end to the press and at the other to the cross-head, supported on live rollers, which cross-head may either abut against a stop or be connected with the lever indicator. After the chain has been proved it is dragged by a second capstan directly forward in the same line into the examining room, and there stretched upon one of the benches, where it undergoes a close inspection. If found perfect it is then hauled forward by a third capstan through the heating oven and blocking trough, and is thence passed complete into the delivery store at the opposite end of the establishment. The course of the chain being thus in one straight line, it is necessary to carry it over the machinery at each end of the testing bench, and to accomplish this a channel of wrought iron is fixed over the machinery to support the chain in its passage. Should the chain fail in the test, or be found defective on examination, it is drawn off by one of the capstans to the smiths' fires, placed on the floor of the examining room, and after repair is again hauled to the testing bench for a second proof. For the convenience of handling heavy chains at the smiths' fires, a hydraulic crane is connected with each fire. Between the testing and examining rooms there is an intermediate room, called the indicator room, in which the lever and hydraulic indicators are placed, and the valves of the apparatus manipulated by an attendant in view of the indicators.

Anchors are received into the same store room as the chains, and the usual appliances are provided for fixing them in the test. Overhead cranes are employed for lifting the anchors as well as for lifting the chains in the two stores.

There are two testing machines in the establishment, fixed at opposite sides of the room. These are similarly arranged in every respect, but one of them is adapted to test up to a strain of 200 tons and the other to 300 tons.

The hydraulic pressure is supplied from a neighboring accumulator, used for a system of hydraulic machinery, at work in the adjacent dock.

As the general practice is to make chain cable in lengths of fifteen fathoms, the Birkenhead machines are adapted for that length. The Board of Trade have recently fixed upon that length as the limit of length of chain to be tested at one time. The propriety of their so doing has been called in question, but I may state that it is the opinion of those persons who have the management of the Birkenhead machines, that no advantage of any kind would be gained by testing chains in greater lengths. If there is to be a limit it is clear that such limit is best fixed at the length at which chains are usually made. There is, besides, a positive objection to exceeding that limit, because a greater length than fifteen fathoms cannot be tested without the use of intermediate supports, which, whether they be slides or rollers, are objec-

tionable as being liable to produce variations of strain in different parts of the chain.

Another objection to permitting indefinite lengths of chain to be tested at one time arises out of the stretch to which chains are subjected in testing. This stretch occasionally amounts to five feet in fifteen fathoms, and if that length of chain were greatly exceeded, it would involve a press of very inconvenient length, or necessitate taking repeated holds of the chain, which would be highly objectionable. I think, therefore, that the Board of Trade have acted wisely in imposing a limit and in fixing that limit at fifteen fathoms.

Proc. Brit. Association.

Explosive Compound.

From the London Mechanics' Magazine, September, 1865.

In the *Mechanics' Magazine* for August 11 an account was given of some Swedish experiments with that highly explosive compound, nitro-glycerine, which Mr. Nobel, a Swedish engineer, is endeavoring to bring into use, instead of gunpowder, for blasting purposes. The same "blasting oil," as Mr. Nobel calls it, has since been experimented with in Cornwall, with very satisfactory results. It is an oily fluid, of a light yellow color, and of 1·6 specific gravity. It consists of three atoms of nitric acid, or $3\,N\,O^5$, combined with one atom of glycerine, or $C^6\,H^5\,O^3$, so that its ultimate composition may be represented by $C^6\,H^5\,O^{18}\,N$. It bears the temperature of boiling water without explosion or injury, but explodes at about 360° Fahr. The changes which occur during explosion, convert each volume of it into 469 volumes of carbonic acid, 554 volumes of steam, 39 volumes of oxygen, and 236 volumes of nitrogen, being a total of 1298 volumes of gas for each volume of the liquid oil. The gases produced by the explosion of gunpowder measure, when cold, only 250 times the bulk of the gunpowder exploded, so that, supposing the gases evolved to be in each case at the same temperature, nitro-glycerine would thus be five times more effective than its bulk of gunpowder. A great deal more heat, however, is generated by the explosion of nitro-glycerine than by the explosion of gunpowder, and the gases produced by the explosion of the former are therefore in so much higher a state of tension than those produced during the explosion of the latter that the new agent is really thirteen times more effective, bulk for bulk, and eight times more effective, weight for weight, than the old. The use of nitro-glycerine in blasting, therefore, enables thirteen times more disruptive force to be applied, by means of a hole of a given size, than can be brought to bear by means of a bore of the same dimensions when gunpowder is used, and one result of its substitution for gunpowder, for blasting purposes, is thus a very great economy of labor. When there are rents in the rock in which the bore is made, the advantage of nitro-glycerine over gunpowder is greater than thirteen to one, amounting, indeed, to between twenty and thirty to one, by reason of the explosion of nitro-glycerine being so much more rapid than

that of gunpowder that the force of its explosion is not appreciably diminished by fissures in the bore which would diminish the effective force of an explosion of gunpowder by fifty per cent. For the same reason, "tamping is never required, a shaft of loose sand being sufficient in all cases. Hence, accidents in charging are impossible, besides the saving in time." Other advantages of nitro-glycerine are that, "being insoluble, discharges under water, or in water-carrying rocks, may be effected by it without cartridges; and, as the blasting oil can only be exploded under certain conditions, and by means of igniters manufactured specially for the purpose, its storing and transport involve no danger." Curiously enough, contact with fire is not sufficient to ignite it at ordinary temperatures, neither is contact with phosphorus, or even with potassium. The chief danger in its use is from its intensely poisonous qualities, but these can be effectually guarded against without much trouble. At present, nitro-glycerine is more costly than gunpowder in about the proportion which it is more effective, so that, for charges of equal force, nitro-glycerine and gunpowder cost about the same. The saving of labor and time which results from the use of the former, however, renders it by far the more economical agent of the two.

On Surface Condensation. By Otto Dingler and Franz Pfeiffer, Engineers to the Austrian Lloyds.

From the London Artizan, November, 1865.

Great differences of opinion exist as to the amount of saving in fuel to be derived in marine engines from condensation of steam on cold surfaces, as compared with that obtained by the injection of water. The theoretical gain which may be realized by feeding the boiler with distilled instead of salt water may be readily calculated, the balance in favor of distilled water being equal to the loss represented by the blowing off and scumming required when salt water is used.

The real loss of heat, however, is likely to exceed that found by this calculation, as in all probability a certain quantity of the steam generated will be carried away through the outlet pipe with the waste water, in consequence of the continual oscillations in the level of the water. These quantities, which are thus uselessly abstracted from the boiler, have not to our knowledge ever been measured, but such measurement may readily be made in the following manner:

Supposing the outlet pipe, instead of issuing overboard, to be led into a vessel containing x kilogrammes of water at a temperature t, this quantity will, after the lapse of a certain time, which may easily be measured, have increased to y kilogrammes and assumed a temperature t'. The quantity of heat contained in the original quantity of water was $= x \times t$, the quantity of heat contained in the y kilogrammes is $= y \times t'$ units of heat, therefore the increase representing the abstraction of heat from the boiler will be $y \times t' - x \times t$ units of heat. Now, supposing it had been ascertained by simultaneous direct mea-

surement that, during the same lapse of time z kilogrammes of water of a temperature t' had been let into the boiler, there will obviously remain

$$z-(y-x)=z+x-y \text{ kilogrammes}$$

that had been usefully employed and required for their evaporation

$$(z+x-y)(650-t'') \text{ units of heat,}$$

so that the loss of heat involved by the blowing off will be represented by the expression

$$\frac{y\,t'-x\,t}{(z+x-y)(-t'')} \text{ units of heat.}$$

In order successfully to perform such an experiment, the following points should be kept in view: The vessel in question should be as large as possible, and the quantity of water (x) contained therein originally be of a temperature sufficiently low that the duration of the trial may not be too short, and the steam may be readily condensed. The vessel should be clothed with a non-conducting material, the inlet taking place from below, an aperture of sufficient size being provided for the escape of the air. On the other hand, the steam generated in the boiler and supplied to the engine, representing the quantity of heat usefully employed, should not be liable to priming, and this condition may be complied with, at least with an exactitude sufficient for practical purposes.

We have observed that a loss of heat is involved by a certain quantity of steam being carried off when the saline water is let out of the boiler. The question arises, in what proportion water and steam may be mixed together in this case, and though this question is immaterial from a mere practical, it is sufficiently interesting from a scientific point of view to justify its being inquired into. This may be done in one of two manners.

If we subtract from the measured *total* loss of heat, as above, the calculated loss that would take place if water only were abstracted from the boiler, the difference between these two will represent the quantity of heat uselessly abstracted from the boiler by the steam that has been carried off, and from this the weight of such steam may be readily deduced. Another method is as follows: Letters denoting the same as above, and supposing T to be the temperature in the boiler, n the quantity of water, and m the quantity of steam (in kilogrammes) abstracted from the boiler in the manner alluded to, it is obvious that

$$y\,t'-x\,t=n\,(\mathrm{T}-t)+m\,(650-t),$$

and as

$$n+m=y-x,$$

we find for the quantity of steam in question

$$m=\frac{y\,t'-2\,x\,t-y\,\mathrm{T}+y\,t+\times\,\mathrm{T}}{650-\mathrm{T}}.$$

The accurate carrying out of a series of experiments in the described manner would tend to do away with the prevailing differences of opin-

ion on the saving of fuel that may be realized by the use of distilled water in the feeding of boilers, and lead to a proper appreciation of this saving. The latter, however, is not the sole element acting in favor of surface condensation. The question also arises whether the durability of the boiler may not be affected by feeding it with a different kind of water. On this point, however, the most contradictory and peculiar opinions are met with. This much, however, seems certain, that boilers working with distilled water are liable to a far greater internal oxidation than those in which the deposits of salt prevent a direct contact between the metal and the salt water. The naval engineers of all countries are engaged at present in inquiring into the causes of this increased corrosion, and many controversies have arisen on this subject without having yielded as yet any result beyond the following four hypothetical explanations of the phenomena of oxidation observed in boilers working with surface condensers, viz:

1st. The sulphur contained in the vulcanized india rubber rings used for the packing of the condensation pipes is partly absorbed by the feed water and transmitted to the boiler itself, and the metal is stated to be affected by the corrosive action of such sulphur.

2d. In a manner similar to No. 1, copper derived from the condensation, feed, and steam pipes is supposed to be deposited on the sides of the boiler, where it would produce galvanic effects.

3d. Distilled water is stated to have the property of affecting iron in a higher degree than impure or common spring water.

4th. The greasy substances from the steam cylinders, pumps, &c., introduced into the boiler with the feed water, form acids which generate a decomposing action, which operates destructively on the boiler plate.

We need not enumerate all the *pros* and *cons* urged with reference to these hypotheses, but content ourselves with observing that the supporters of the two first-named suppositions, which are obviously the weakest of all, seem to attribute to the decillionth parts of a grain of sulphur or copper, a very powerful homœpathic action on the colossal masses of iron of the boiler. As regards the supposed action of distilled water, for which no scientific reason can be adduced, our own extended experience enables us to utterly deny it, and we request more particularly engineers engaged in the manufacture of sugar to ascertain with accuracy when a boiler, affected in the manner alluded to, has always been fed with *pure distilled* water, or if the water supplied to the boiler contained a *per centage of sugar*, derived from such apparatus as may have become leaky, as we notice that, in this quarter, the assertions of the injurious effect of distilled water have been chiefly urged and supported. We also have often met with boiler water as black as ink, but only in cases when foreign substances had found their way into the steam generator. On the other hand we certainly profess the opinion that acids produced by *greasy* substances do, indeed, act destructively on iron, and this view of ours as to the injurious effect of such acids, as well as carburetted hydrogen, is corroborated by the above-mentioned experience relating to feed water mixed

with sugar and syrup, and also by the fact, not generally known to engineers, that iron and steel are very injuriously acted upon by heavy liquid carburetted hydrogen substances.*

On the sides of boilers fed with distilled water, (and more particularly at the height where the level of the water changes, *i.e.* within the limits of the water level,) a deposit consisting of incrustation, grease, and some oxide of iron may be found, which preserves the boiler plate from the contact of the water, there being no adhesion between the water on this rough but very greasy mass. The flues also are covered with a similar deposit, less greasy in appearance, the existence of which alone should suffice to render questionable the destructive action of *pure* distilled water.

The high temperature of surfaces that are encircled by fire, prevented from contact with water by the deposit alluded to, and consequently very liable to incandescence, and the corresponding high temperature of the deposits themselves, are amply sufficient to decompose the greasy matter, by which the gas generated in the process of decomposition will tear up the incrustation, allowing the water a free access to the overheated iron. Though neither the small quantity of hydrogen gas generated thereby, nor the excessive instantaneous production of steam may be attended by any danger, still the partial oxidation of the boiler plate cannot be denied, and this process being repeated an infinite number of times, its consequences must become perceptible at length. It is obvious that the minor explosions that are repeatedly observed, as well as the noise that is audible at times, are easily accounted for by this phenomenon.

By the combustion of grease, however, several products, such as combustible oils, acids, &c., are generated, the action of which on metallic iron—though at present not yet sufficiently known—cannot be denied, as will appear from the above statements. The fact of the boiler plates being chiefly affected at the height of the level of the water, may be easily accounted for by the separation of portions of the deposit alluded to, effected by the fluctuations of the water, and subsequent action of the acids thus freed, upon the denuded metallic iron surface.†

From this it is clear that, to explain the speedy destruction of the boiler plates, a galvanic action, or a peculiar, not yet discovered, pro-

* During four years we have observed, at least once a week, that the iron and even steel valves and steel wire spiral springs of a force pump for gas were decomposed by such substances containing carburetted hydrogen, benzine, euplion, &c., as were separated from the gas at a pressure of from 25 to 30 atmospheres, and had to be let out of the pump every hour. The valves that were made of best English cast steel, after iron had proved inefficient, were corroded by this liquid, which gave them the look of raw Damascus steel, and the steel springs were unwound like raw cord. The gas in question was prepared out of distilled colophorium (so-called colophorium oil) and was free of all foreign substances.

† Some have tried to deny the pernicious action of acids of grease on boiler plates, urging that, by the introduction of alkalis into the boiler for the saponification of grease, the oxidation of iron could not be stopped; but by this they do not prove the non-existence of acids of grease, but merely that fuller's earth acts on iron in the same manner as non-saponized acids of grease.

perty of distilled water need not be resorted to, these hypotheses being as preposterous as the alleged formation of oxygen and hydrogen gas, and its ignition by a spark produced inside the boiler, (*sic.*,) the dangerous increase of the pressure of steam by hydrogen gas accompanying it, and so forth.

The question arises, how to neutralize the injurious action of these acids of grease on the metal of the boiler? As we have observed previously the incrustations of salt preserve the plate from immediate contact, and consequently from the injurious action of the boiler water, or rather of those foreign substances contained therein. It would, therefore, be requisite only to give the sides of the boiler a light coating by feeding it with salt water from the commencement. This preventive is usually resorted to in practice, but by this protective process the greasy substances are not removed, but will accumulate in the boiler, and, unless removed from time to time by blowing out, they will form over the incrustation of salt the thick deposits alluded to, thus exposing the plates to the danger of combustion and contracting the steam and water space of the boiler. If, however, the remedy of blowing off these substances be resorted to, rather considerable losses of heat are occasioned, which will counterbalance a portion of the advantages derived from the production of steam from distilled water. It follows that the problem to be solved consists in preventing these greasy acids entering the boiler at all, *i.e.* in abstracting them from the feed water before it finds its way into the boiler. As far back as two years ago we have been engaged in the solution of this problem, and thought of the employment of a coal filter to remove the grease from the water on its way from the condenser to the boiler, a very old principle, which was patented for England recently by one Mr. James Howden.

Unfortunately we were not in a position to make experiments on a large scale, though those made on a small scale yielded excellent results. We therefore agree with the patentee, but would suggest to use, instead of one filter, two filtration apparatus, constructed more in keeping with the purpose, more readily accessible and separate from the engine, and arrange them so that the one may be cleaned, *i.e.* the coal powder impregnated with grease be replaced by a fresh filling, while the other is at work. In this manner the clarification of the water might take place without any interruption of the working of the engine. The waste coal from the filter might be revived by washing and baking, and the grease be saponized or used as a lighting material.

A marine boiler, fed with distilled or clarified water, will work under no less favorable conditions than a stationary boiler, and it is to be expected that, by preventing the external oxidation very frequently on board ships, its durability may be rendered almost equal to that of a stationary boiler. To obtain this result it would be necessary to put the shell of the barrel, which in a marine boiler is destroyed first, into a condition identical with that in stationary boilers. The more intense corrosion in the barrel in feeding with salt water is produced on the

one hand by the fact that no protective incrustation is formed above the level of the water, and consequently the salt water, raised mechanically by the balancing of the ship and the ascending steam bubbles, will cover the metallic sides; on the other hand, by the method at present in use of constructing marine boilers, the chimney hood will pass across the barrel of the boiler, and form a heating surface surrounded by steam, not by water, and it is just at the level of the chimney hood that the corrosion will be strongest, a fact which is easily accounted for.

In the quick heating of the cold boiler, this part, which is touched neither by water nor steam but by the flame itself, may soon get up to incandescent heat, and this may take place through strong heating, even during the voyage, especially when flues, tubes, &c., are covered only with a thin coating of incrustation, and the gaseous products of combustion passing through are no longer properly cooled. In this case the red-hot plate will obviously be oxidized. The chimney hood not being covered with incrustation, the nascent protoxide of iron may be separated by the change of the temperature produced by spray, or dissolved by the acids of grease and their vapors, by means of which the formation of a new layer of protoxide is facilitated.

In feeding, however, the steam generator with *pure* water, oxidation of the plates cannot take place in the barrel any more than in any other part of the boiler, and, as regards the usual chimney hood, it will involve no constructive difficulties to suppress it altogether, and in lieu thereof lead the gases derived from the combustion immediately out of the boiler after their passage through the tubes, and pass them into a copper superheating apparatus at the front of the boiler and thence into the chimney. In such arrangement *all* iron heating surfaces will be surrounded by the water of the boiler, and as copper is not destroyed by superheating, all postulates will be complied with to secure to marine boilers a durability equal to that of stationary boilers. The additional expense for copper instead of iron in the superheating apparatus would be amply balanced by the economical advantages realized in other respects.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, December 20, 1865.

The meeting was called to order with the Vice President, John H. Towne, Esq., in the chair.

The minutes of the last meeting were read and approved. The minutes of the Board of Managers were reported, including the following resignations: Messrs. Frederick Graff, Wm. A. Mitchell, and George Harding; and the following donations to the library: From the Royal Society, the Royal Astronomical Society, and the Institute of Actuaries, London; the Canadian Institute, Toronto, and the Natural History Society of Montreal, Canada; the Nova Scotian Institute of Natural Sciences, Halifax, Nova Scotia; Capt. J. M. Gilliss, Super-

intendent U. S. Naval Observatory, the Agricultural Department, and Frederick Emmerick, Esq., Washington, D. C; Thomas W. Bakewell, Esq., Cincinnati, Ohio; and Prof. John F. Frazer, Philadelphia.

The various Standing Committees reported their minutes, and the Special Committee on experiments in steam expansion reported progress.

On motion of Prof. John F. Frazer, the meeting then went into nomination of officers for the ensuing year, when the following nominations were made: For President, Wm. Sellers, Esq.; Vice President, J. H. Towne; Secretary, Henry Morton; Treasurer, Frederick Fraley.

For the Board of Managers to fill the places of those whose term of office has expired: Washington Jones, Esq., B. H. Bartol, C. H. Cramp, P. E. Chase, C. S. Close, J. H. Whitney, James Dougherty, J. V. Merrick, and Robert C. Cornelius.

To fill the vacancies caused by resignations from the Board: Wm. B. Bement, John Rice, Edward Y. Townsend.

For Auditor, Samuel Mason. The President then appointed for Judges of Election, George Erety, Samuel Hart, James H. Cresson, Wm. Biddle, James T. Morris, Charles McManus, Clarence S. Bement.

Prof. FAIRMAN ROGERS read a paper upon the magnetism of iron vessels and the methods of correcting ships' compasses. The investigations and experiments of Poisson, Airy, Evans, and Smith were described, and the results at which they had arrived explained and commented upon.

The fundamental equation representing the action of the ship upon the compass was considered, and the mode of calculating the magnetic elements of the ship, from a series of observations, explained.

The speaker suggested that the subject possessed great interest at this time, owing to the large number of iron vessels in our navy, and to the unusual forms of many of them. Experiments and observations are going on under the care of the Compass Commission appointed by the government, and by officers especially detailed by the Department, which will undoubtedly add something to the stock of knowledge upon several points yet requiring further elucidation.

The methods now in use of correcting the errors of ships' compasses mechanically, and some new forms of compass devised for the purpose of overcoming difficulties, were described.

The Report of the Resident Secretary on new inventions and discoveries was then read as follows:

SECRETARY'S REPORT.

We see from a paper read by Mr. Prentice, before the British Association, that the use of gun-cotton in mining operations is decidedly increasing, and that this substance appears to possess, among other advantages, the great merit of producing a smoke less in quantity and far less injurious in effect than gunpowder or other similar compounds. This statement is fully substantiated by the report of the Commis-

sioners on Mines of Great Britain. For soft rock the efficiency of the charge is greatly increased by winding the cotton on a light wooden core, and thus diffusing it. This was, of course, to be expected from the experiments of Prof. Abel, published in the *Journal* of this Institute, volume xlix, pages 37, 133, and 189.

The material beton, now receiving so general and extended an application, has been lately used in Paris for the construction of arched floors in some extensive barracks.

The material is simply moulded on timber centerings placed between the walls, which are 13 feet apart, and when it has set, these are removed, leaving the beton arches to support themselves. These arches having, as already indicated, a spring of 13 feet, are 2 feet thick at the spring and 10 inches at the crown.

The underground tube or tunnel of the London Pneumatic Despatch Railway, has been finished from Holborn to Easton Station, a distance of two miles. The diameter of the tube is 4 feet 6 inches. A train of goods with an attendant was sent through the whole distance in five minutes.

In a paper on weldless tires, read before the British Institution of Civil Engineers, by F. J. Bramwell, C.E., we find a full description of the manufacture, according to Bodmer's principle, of these articles. In brief, this is as follows: A helical coil of bar iron is made up, welded, and rolled into a tire of double the thickness and half the diameter required in the finished article. This is then worked down to the required form in the continuous rolling machine adapted for such operations.

By the Bessemer process, steel is being manufactured and worked into rails, &c., at the Crewe Locomotive Works, a double steam hammer being used in the forging, and the spectroscope employed as a means of observation, and prospectively as a guide in the process of conversion.

In looking over the set of abstracts of the proceedings of the Royal Institution, which have been just received, we notice several papers of an interesting character, relating to the physical constitution of the sun. It is worthy of remark, however, that though these papers seem to be the result of very elaborate observations, research, and comparisons, they develop little that is new; serving chiefly to confirm the observations and conclusions published long ago by Herschel. Thus we have, in the first place, a paper On the Nature of Sun Spots, by W. De la Rue, Balfour Stewart, and Benjamin Loewy. By comparison of extensive tables showing the behavior of sun spots in various positions, these gentlemen find that of those near the equator, 86 per ct. act as if the spot were a hollow, 14 per ct. in discordance with that supposition. Of the spots observed in high solar latitudes, 80·9 per ct. agree with, and 19·1 per ct. oppose the same hypothesis. Again, in observations made on the position of the faculæ or ridges of luminous matter accompanying sun spots, out of 1137 observations, in 584 cases the faculæ were on the left of the spot, in 508 equally distributed, and in 45 cases only were most on the right of the spot. This

leads to the conclusion that these faculæ consist of luminous matter projected from the locality of the spot, and, coming into a higher region of more rapid absolute motion, fall back in the general rotation of the whole system. It was also occasionally observed that bridges of this luminous matter, and even detached portions, crossed the spots without being accompanied by any penumbra.

In a second part of the same paper are recorded observations from which it would appear that the formation of sun spots is connected with the influence of the planet Venus, these being restrained and checked when she is in front of the sun, and increased in her absence.

In another paper On the Physical Aspect of the Sun, by John Phillips, reasons are shown for regarding the sun spots as *very shallow* depressions.

Physics.—Two papers in the same abstracts, record experiments by Balfour Stewart and P. G. Tait, which seem to indicate that the mere act of rotation of a body, such as a disk of wood or metal, will cause it to give off radiant heat, irrespective of any effect of friction against the air or other like medium. Thus, it was found that the disk being rotated in an exhausted receiver, and giving out more heat than when it was at rest, no change was produced in the amount of its radiation by a notable variation of the tension of the air in the receiver, or even when the vacuum was made upon hydrogen.

In the *Comptes Rendus* of the French Academy, we find the statement by M. Bultinck, that by the substitution of magnesium for zinc in the intenser forms of galvanic piles, as good an effect may be obtained with pure water for the exciting liquid, as could be reached with the latter metal by employing an acid or saline solution. For medical purposes, where short duration, intense current, and cleanliness of materials are the main objects, such an arrangement may be of value.

Mr. Carey Lea, of this city, states that he has found the operation of plating glass by deposit of metallic silver from solution, greatly facilitated by the action of strong sunlight, and recommends the exposure of the plate, prepared with its layer of solution, to the direct sun rays for from fifteen minutes to the time required to dry up the solution, according to the thickness of coating desired.

M. Fremy, in the course of his examinations regarding the nature, actions, &c., of hydraulic cement, finds that the aluminates of lime, when fused, absorb sulphur and phosphorus, and are also more fusible than the corresponding silicates. These facts are of importance in the reduction of metallic ores generally.

Deville mixes alumina and pounded marble in equal parts, heats this highly, and then mixes the resultant so obtained with an equal quantity of alumina obtained by the decomposition of ammonia alum at the lowest possible temperature. He thus obtains a substance from which to manufacture refractory crucibles of remarkable endurance.

A mixture of thoroughly dried clay with about half its weight of glycerine, is stated in the *Cosmos* to furnish a good substitute for wax in modeling.

Ilmenium, a new element, first announced by the chemist Hermann in 1845, and whose elementary character was denied by Rose and Blomstrand, is now re-announced by its original discoverer.

Pelouze has shown that as sulphur gives to glass a yellow tint, so selenium communicates an orange tint.

A process is now used in London by which statuette likenesses, busts, &c., may be produced in clay or plaster at a small cost by the aid of photography. The operation is as follows: Eight photographs are taken of the sitter from eight "sides." From each of these profiles are cut out in thin sheet metal. Each pair of profiles are caused to plane away the sides of a block of clay corresponding to the position in which their photograph was taken. Thus, the clay comes to have on each side the same profile as that of the sitter, and is thus a likeness requiring but a few touches from the artist to give it finish and exactness.

It appears that the "carbon printing" photographic process has been applied to the permanent ornamentation of porcelain with success, any material fit for burning into that substance being substituted for the carbon or india ink of the original operation.

Mr. J. N. Herder, in a lecture lately delivered, shows that if powder, rendered non-explosive by Gale's process, is gently jarred or shaken for a few minutes, the coarser particles of the powder rise up, while the finer sand, glass, or the like, settles down, and thus the mixture loses its protection and is as explosive as ever.

Mr. Warren De la Rue has taken many good photographs of the late lunar eclipse, and by combining one of these with a similar picture taken on a previous occasion, has produced a stereoscopic view giving a remarkable effect.

The attention of the meeting was then called to a new form of the magnesium lamp, manufactured by the American Magnesium Company, of Boston. It burns with great steadiness and certainty, and gives a light decidedly brighter than that obtained from an excellent oxohydrogen lime light. (This was demonstrated by actual comparison, and photometric measurement, executed in presence of the meeting.) In this lamp the clock-work feeds forward a double strip of magnesium ribbon, and trims off the ash as it forms; a method is also in use for "fixing" some of the smoke. No difficulty is experienced in the use of this apparatus from the deposit of the magnesia smoke upon the glasses placed in front of the light to diffuse or color it, and subsequent experiments indicated the possibility of using this light behind lenses in the rougher sort of optical apparatus, such as the magic lantern.

A curious phenomenon, before recorded, was strikingly exhibited in the course of some of the experiments tried at this meeting.

When the light from either of the sources was colored by passing through stained glass, the shadows of objects thrown from that light were of the complementary color, though the points so shaded were illuminated by pure white light only, from the other source.

After some questions and remarks upon this subject, the meeting was, on motion, adjourned.

H. MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

The Student's Practical Chemistry; a Text-book on Chemical Physics and Inorganic and Organic Chemistry. By HENRY MORTON, A.M., and ALBERT R. LEEDS, A.M. Philadelphia: J. B. Lippincott & Co., 1866. 12 mo., pp. 311.

This neat little volume is intended simply as a text-book, and more especially as a text-book for those attending the lectures of the Franklin Institute. It is intended as a popular explanation of the principal phenomena of physical science, and avoids much detail and all technically mathematical expositions. Its teaching is exclusively experimental and intended for beginners only. There is no doubt there is room for such a work among those daily issuing from our press, and a great desire among readers to possess such a manual. Without questioning the ultimate advantage of gratifying such desire, it is but fair to say that this little treatise is excellent of its kind, clear in its statements, lucid in its explanations, the experiments well selected for the demonstration of the desired phenomenon, and the book very well illustrated with wood-cuts. Great care has also been used to bring it down to the date of its publication, so that the reader will find in its pages an account of all the principal new discoveries in physical science. These remarks apply peculiarly to the branch of chemical physics; the chemistry proper would probably be improved by a careful revision in a future edition. The work is put before the public in excellent type and in a style creditable to its well known publishers.

On the Strength of Cast Iron Pillars, with Tables for the use of Engineers, Architects, and Builders. By JAMES B. FRANCIS, Civil Engineer. Extracted from the proceedings of the American Academy of Arts and Sciences. New York: Van Nostrand, 1865. 8 mo., pp. 71.

This memoir begins with an account of the experiments of Hodgkinson, which form the basis of all our formulæ and tables for strength of cast iron. This account is followed by the rules for calculating the strength, and by a series of tables of the safe weights for cast iron pillars of lengths from 8 to 30 feet, and outside diameters from 2 to 10 inches. It is, of course, a strictly practical and professional work, which none but the professions interested will fully appreciate, but which every member of these professions will desire to have for constant reference. It is, of course, cleanly and beautifully printed, and handsomely got out by the publisher.

A Comparison of some of the Meteorological Phenomena of NOVEMBER, 1865, *with those of* NOVEMBER, 1864, *and of the same month for* FIFTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	November, 1865.	November, 1864.	November, for 15 years.
Thermometer—Highest—degree, .	66·00°	69·00°	80·00°
" " date, .	17th.	30th.	1st, '60.
" Warmest day—mean,	62·33	65·17	72·30
" " " date,	17th.	9th.	9th, '57.
" Lowest—degree, .	26·00	25·00	16·00
" " date, .	11th.	24th.	25th, '60.
" Coldest day—mean,	33·00	28·83	23·30
" " " date, .	11th.	23d.	25th, '60.
" Mean daily oscillation,	11·63	10·80	13·16
" " " range, .	4·73	5·84	5·65
" Means at 7 A. M., .	41·43	41·30	41·20
" " 2 P. M., .	49·63	49·22	50·24
" " 9 P. M., .	44·45	44·57	44·41
" " for the month,	45·17	45·03	45·28
Barometer—Highest—inches, .	30·405 ins.	30·347 ins.	30·661 ins.
" " date, . .	10th.	25th.	12th, '51.
" Greatest mean daily press.	30·387	30·321	30·520
" " date, . .	11th.	24th.	12th, '51.
" Lowest—inches, . .	29·395	29·080	29·080
" " date, . .	22d.	4th.	4th, '64.
" Least mean daily press.,	29·443	29·150	29·150
" " date, . .	22d.	4th.	4th, '64.
" Mean daily range, .	0·156	0·208	0·184
" Means at 7 A. M., .	29·901	29·848	29·909
" " 2 P. M., .	29·837	29·803	29·864
" " 9 P. M., .	29·877	29·849	29·896
" " for the month, .	29·872	29·833	29·890
Force of Vapor—Greatest—inches,	0·534 in.	0·548 in.	0·832 in.
" " " date, .	17th.	10th.	8th, '57.
" " Least—inches, .	·094	·082	·055
" " " date, .	28th.	24th.	25th, '57.
" " Means at 7 A. M., .	·201	·218	·223
" " " 2 P. M., .	·218	·227	·229
" " " 9 P. M., .	·217	·227	·232
" " " for the month,	·212	·224	·228
Relative Humidity—Greatest—per ct.,	96 0 per ct.	94·0 per ct.	100·0 per ct.
" " " date,	21st.	7th.	often.
" " Least—per ct.,	33·0	30·0	25·0
" " " date, .	13th.	30th.	7th, '63.
" " Means at 7 A. M.,	74·6	76·2	77·2
" " " 2 P. M.,	58·7	60·9	59·0
" " " 9 P. M.,	70·2	72·2	73·3
" " " for the month	67·8	69·8	69·8
Clouds—Number of clear days,* .	12	5	8·5
" " cloudy days, .	18	25	21·5
" Means of sky cov'd at 7 A. M.,	57·7 per ct.	72·7 per ct.	60·6 per ct.
" " " " 2 P. M.,	55·0	73·0	60·5
" " " " 9 P. M.,	39·3	59·7	52·0
" " " for the month	50·7	68 5	57·7
Rain—Amount,	3·598 ins.	4·065 ins.	3·766 ins.
No. of days on which Rain fell,	6	13	10·3
Prevailing Winds—Times in 1000,	N51°46′w ·255	s83° 40′w ·269	N71°34′w ·262

* Sky one-third or less covered at the hours of observation.